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THE

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[THIRD SERIES.]

ART. XIX.—*Notes on the Geology of Florida;* by WILLIAM H. DALL, U. S. Geological Survey.*

THE object of this paper is to bring out some new facts in the geology of southern and central Florida, obtained by the writer, during two journeys undertaken by instruction of the Director of the U. S. Geological Survey in 1885 and 1887, respectively.

In Southwestern Florida the geological formations have been but little studied. The only geologist of late years who has published anything in regard to the structure of this part of the peninsula, is Professor Heilprin, of Philadelphia. In company with Mr. Joseph Willcox, Professor Heilprin visited a number of points between Tampa and Lake Okeechobee in the winter of 1885–6. Only a part of his report has yet appeared and this is chiefly devoted to descriptions of new species of fossils.† The early papers of Conrad and Agassiz, treating of the vicinity of Tampa and of the Florida Keys; and a compiled résumé of our knowledge of the Tertiary strata of the eastern United States by Heilprin, incidentally treating of South Florida, have been the chief sources of information available until the present year.

* Published by permission of the Director of the Survey. Read before the National Academy, April 21, 1887.

† The whole has appeared since this was put in type.

In referring to the age of the deposits, while the old terms Miocene, Pliocene, etc., may be used for the sake of convenience, it must be clearly understood that, as at present defined, they are only of relative value and indicative at most of stratigraphical succession in a very limited sense. As determined by their invertebrate fauna, the Pliocene, for instance, of South Europe, is probably older than the strata called Pliocene in America, at all events, it is highly improbable that they represent synchronous geological epochs. The method of determining which name should be used for a particular division of the Tertiary, by taking percentages of the supposed extinct species, is, on the face of it, impracticable, illogical and misleading. Our knowledge of the Tertiary in America is still so fragmentary and imperfect as to render a sychronic sub-division of all the Post-Cretaceous strata impossible for the present.

Contemporaneous formations.

A large part of Southwestern Florida is covered with a sandy stratum which may average between two and five feet in thickness and has its upper surface more or less mixed with, or concealed by, the superficial humus. Although in the northern part of the State, ridges marking former boundaries of large lakes rise to more than two hundred feet above the sea, in the southern part the highest elevation is much less, and I have been informed that the rim separating Lake Okeechobee from the lowlands stretching to the Gulf of Mexico, was found by the Canal Company's engineers to be only some twenty feet high, a large part of which is composed of peaty vegetable matter. In the section afforded by the river below Fort Thompson and between it and the Gulf, nothing over fifteen feet in height was observed by us, though the land may rise somewhat higher, away from the river. A large part of the sand is derived from the wear of the limestone rocks which are webbed and clotted with bands, strings and irregular masses of silica, from the Miocene up, and over much of the State, though very irregularly distributed. But on the shores of the Gulf among the purer siliceous sand I observed that there are also particles of crystalline rocks foreign to the region and which occasionally are found in pieces weighing several ounces. The distribution of these particles and pebbles seems too general to permit of referring them to casual discharges of ballast by vessels.

The process of rock-formation is going on in a more obvious manner than would be expected along the Gulf shores of West Florida. There is a general opinion among the inhabitants, which was frequently expressed to me, in conversation, to the

effect that between Tampa and the Keys, coquina-rock is only to be found at one place, the mouth of Little Sarasota Pass. But this idea is certainly erroneous, as at every projecting point of the Keys along the Gulf shore which we visited, I found traces of this rock, though often not visible above water, and frequently composed more of sand-grains than of shell, so that it looks much like wet loaf sugar. It is doubtless being formed at many points along the Gulf shore, though in small quantities at each place, and not at all in the lagoons and harbors.

Another species of rock which strikes a northern observer as curious, is in process of formation by immense compact colonies of *Vermetus nigricans*, which raise the orifices of their minute blackish tubes to several inches above low water mark, and in some of the larger bays have formed extensive reefs. The animal has been supposed to be a worm, belonging among the *Serpulæ*, but I was able to determine its proper place by an examination of the soft parts. I have seen none of this rock in a strictly fossil state, though the species seems to occur in the Caloosahatchie Pliocene, but it is locally known as "worm-rock" and many of the "rocks" described by the natives of this region as cropping out along the shores, turn out on more particular enquiry to be of this kind.

There are three other sorts of rock of which the formation appears to be still going on. One is a more or less indurated sand, which was observed at Myers; also near St. James City on Pine Key; about a mile from the shore of Little Sarasota Bay, on South Creek, where it was found in the banks under the usual layer of sand; and close to the landing wharf at Sarasota, on Big Sarasota Bay. This rock is usually rather soft and contains recent land and a few recent marine shells. In other places, as at St. James City, it becomes extremely hard and compact, ringing under the hammer and almost destitute of fossils. A thin layer of it, from a mere film to three inches thick, marks the upper surface of the much older outcrop at White Beach, Little Sarasota Bay.

A second variety of rock is formed by springs containing iron in solution, which are numerous along the main shore as in both Sarasota Bays. This water consolidates the gravel, sand, shells, etc., over which it passes, into something resembling coquina, but in which the fragments of shell, etc., are united together by a cement of limonite. A spring near the estate of Judge Webb at Osprey, has thus affected a considerable part of what appears to be an Indian shell-heap; and among the shells, etc., in the rock may be detected fragments of pottery. Specimens showing this were brought home, and it is probable that the human remains discovered by Professor Heil-

prin in Sarasota Bay, which were replaced by a pseudomorph of limonite, are of similar origin and about equal age; although I was not able to visit the locality to verify this supposition.

The third variety I have not seen actually in formation, and it has not been observed on the western coast, but occurs along the upper St. John's River and about Lake Monroe, where I observed it in 1885. This is a sand rock in which each grain is coated with a pellicle of lime, giving the mass an oolitic appearance. In this rock, on Rock Island in Lake Monroe, Pourtalès and Wyman found the fossil remains of man which created so much excitement some years ago. The rock also contains recent land shells, but I observed no marine fossils. Rock of this character has been formed in Florida from the Miocene up, the phosphatic rock of Northern Florida is a variety of it, in which the limy envelope of the grains contains a certain amount of phosphoric acid.

Tertiary Rocks.

The blanket of sand, usually overgrown with scrub palmetto and cat-briars, which extends over so much of South Florida, renders the task of tracing the underlying strata very difficult. The sections afforded by the river banks and exposed on the sea shore are usually only a few feet above the water, and in the rainy season flooded, yet to these and to artesian borings the observer must go for his information. There are a number of rivers of reasonable size; but a wonderful absence of small streams, which may almost be said not to exist except during the rainy season. The soil and most of the underlying rocks are so porous that at other times all moisture sinks directly below the surface, or forms a marsh of greater or less extent. Clay is very rare and occurs in patches of small area, generally affording bones of extinct mammalia, saurians and tortoises. In northwestern Florida the oolitic phosphatic rock which overlies the Orbitoides limestone is compact enough to afford a bed for streams when it is continuous and forms the top rock. But as soon as the edge of this rock is reached the streams sink. Some notes on this formation, as reported on by Prof. E. Smith, Dr. Neill, and members of the U. S. Geol. Survey, will be found, greatly condensed, in the "Mineral Resources of the U. S." for 1885, under the head of Phosphates. I may add from my report of April, 1885, in regard to this rock, that "from a considerable area, between the localities where it is now found and the margin of the central depression or ancient lake basin of northern central Florida, it has been denuded, only fragments remaining scattered on the hilltops. The denuding agency made gullies or channels in which clay was deposited which, in its turn, has been more or less washed

away leaving only patches, generally in depressions but occasionally in short ridges. The appearance of the contained bones suggests that the animals were mired and then torn to pieces by predatory carnivora. Ashes and burnt clay were found under some of the bones at Hallowell's ranche but there was no evidence of any human agency in this. The fire was probably due to lightning, an every-day occurrence in Florida at the present time. The longitudinal splitting of the long bones sometimes observed, may often be the result of the penetration, and growth in the hollow of the bone, of roots, which might afterwards decay and leave no sign. I have observed roots penetrating the bones on several occasions." These bones are distributed over the State in many localities, especially in Alachua County.

The older rocks of course come out to the northward and along the central part of the peninsula, and the succession of the newer ones is toward the southern extreme end and the Atlantic and Gulf shores. The hypothetical southward extension of the Oligocene (sometimes taken as Eocene) on most recent geological maps now seems erroneous. It is without doubt represented as considerably too great.

Fossiliferous rocks have long been known to exist at Ballast Point, Hillsboro' Bay, near Tampa, where they were observed by Conrad more than 40 years ago. Recently Prof. Heilprin has examined them, referred them to the Miocene, and described a number of interesting species.

Here we find a state of things which is largely repeated in the younger strata to the southward. The rock rises but a few feet above the beach. Two layers may be distinguished, especially by their fossils, for the rocks are so broken up that the superposition of the newer layer here is less clear than I found it farther inland. The older rock is composed of a limestone, which in some places is so impregnated with silex as to form an almost pure flint; and at other spots retains its limy character, or is decomposed into a marl of peculiar tenacity. In many places the marl occurs in pockets surrounded by or covered with chert. In other spots it forms the greater part of the bank; but, however different in character, the chert and marl are merely parts of one stratum which has been subjected to different processes of mineralization in its different parts, and not two strata or rocks. In the chert the fossils, of which the rock is full, have disappeared, leaving cavities from which their forms may be reproduced by moulding in gutta percha. In the marl they have also disappeared but the smaller ones are represented by more or less perfect pseudomorphs of subtranslucent silex, reproducing every detail of the original shell. The larger ones, such as heads of coral, re-

tain their outward form, but are usually mere shells with an interior of botryoidal chalcedony, often of great beauty. The discovery here of *Ecphora quadricostata* by Dr. R. E. C. Stearns in 1869 (as pointed out in Science, vol. vi, p. 82, July 31, 1885) indicates the Miocene age of the rock; a suggestion which Heilprin has confirmed by his study of the silicified fossils collected here in 1885–86. The stratum affording these fossils is not limited to this locality. Conrad found it nine miles up the Hillsborough river which is fourteen miles or so to the northward and eastward from Ballast Point, and I am informed that the silicified fossils occur at various intermediate points along the bay shore. I found the same rock and fossils on Six Mile Creek at the head of navigation, near Orient station, about six miles to the eastward of Tampa, on the South Florida railway.

The fossils are chiefly marine, but there is a certain admixture of landshells which becomes more pronounced toward the top of the bed, indicating a gradual increase of the adjacent land area during the deposition of the bed. Finally, on the upper surface in some places nothing but landshells are found, showing that, at last, it became dry land at least in certain spots.

These landshells are all of extinct species allied more nearly to those of the West Indies than to the present fauna of the Southern States. A small bulimoid shell has been, I think incorrectly, referred to the Pacific genus *Partula*, which it somewhat resembles, as observed by Conrad forty years ago. But it is probably more nearly related to certain recent Bulimi of the northern Mexican and South American faunæ.

Above the stratum above described is a layer, from a foot and a half to ten feet thick, of limestone free from silex and pretty uniform in character. The fossils are mostly represented by external molds; but a few, and particularly an orbitolite described by Conrad, and probably identical with one now living at moderate depths on the Floridian coast, retain their shell structure. Some of the fossils in the lower stratum appear again in this one, but most of the species seem different and there is a notable absence of the large corals so abundant in the older layer. There are more species which seem to be represented in a living state in the present fauna.

This rock underlies the town of Tampa where wells are dug through it, and water obtained at a depth of ten feet or less. It is probable that the more compact cherty stratum underlies it here and forms a water table. The same rock occurs seven miles northeast of Tampa in wells, and also on land belonging to Mr. Lapenotière of Tampa (S.E$\frac{1}{4}$ Sect. 14, T. 29 R.19), near Orient station. Its upper surface is about fourteen feet above Six Mile Creek near by, and about twenty-five feet above the

water in the harbor of Tampa at the railroad wharf, according to recent surveys. Its exact thickness here I was not able to determine. I was informed that the same rock occurred on the Manatee river above Braidentown and still farther to the south and west I observed it about one mile from Sarasota village, on the road from Braidentown, in the gulley of a small rivulet about half a mile from the shore of the bay.

This rock, which is evidently younger than the siliceous stratum, has been referred by Heilprin to the "Yorktown" epoch of Dana or Middle Miocene. There is an outcrop of rock at Bowley's Creek emptying into Sarasota Bay, about eight or nine miles N. W. of Sarasota, and about two miles from its mouth. This can only be reached at high water, and is then a foot or two below the surface. I visited it and succeeded in getting some fragments with prints of two species of *Pecten* and one of *Ostrea*, with traces of a *Spondylus*, all of which are represented either in other Miocene localities or in the outcrops at White Beach, about to be described. The rock was covered with quaternary beds of sand containing recent shells in a semi-fossil condition.

In the northwestern extreme of Little Sarasota Bay there is an outcrop of rock which at high water rises two or three feet above the water. It is a yellowish limestone much waterworn and covered in places with a thin layer of recent sand-rock. It contains distorted molds of many species which cannot be recognized, but in some places these molds have become filled with a pseudomorph in lime of the original shell. These pseudomorphs are gradually exposed by the action of the sea on the rock, and afforded about forty species of molluscan fossils, besides several corals and corallines. The rock did not show any foraminifera, though several of the species of shells are identical with those of the orbitolite stratum of Tampa.

Of the species obtained here eight appeared on a preliminary study to be new or peculiar to this locality; of the others, twelve seemed identical with species of the siliceous beds at Ballast Point, and four more with Miocene species from the island of Jamaica, West Indies, and other localities. Seventeen species, of which eight are supposed to be extinct, were subsequently found in the Caloosahatchie beds, and two are known from other Pliocene deposits. The other nine, with three not obtained on the Caloosahatchie, are believed to survive to the present day in adjacent waters.

While this association of species is probably only a small part of those which comprised the original White Beach fauna, the proportion of forms indicates that the stratum represented, is later than the Tampa Miocene, and that its fauna is transitional toward that of the Caloosahatchie deposits, which

probably followed it at no very great interval, geologically speaking.

The Caloosahatchie River, in the proper sense of the word, begins at the northeastern extreme of the long estuary which bears the name, some distance above the town of Myers.

The banks at first are extremely low and screened by thickets of mangroves which only disappear when the water becomes perfectly fresh. The land appears nearly level. As the river is ascended a close scrutiny shows that it cuts through a succession of gentle waves gradually increasing in height inland, whose crests would show a general parallelism with the direction of the peninsula of Florida, or transverse to the average course of the river. Near the head waters of the river these waves of elevation rise above the level of the river at low water, to a height of perhaps twelve feet at most, and their individual length from one trough to another may average about a quarter of a mile. Though insignificant as flexures they are interesting as showing that a lateral as well as a vertical thrust has attended the movements of the rocks in this part of the State, a fact which has been questioned.

The greatest elevation studied by us extends for several miles between the sites of the old forts Thompson and Deneaud. At the former point the canal from Lake Okeechobee enters the river, its bed being a compact rock which had to be blasted out. The succession of the strata is perfectly uniform, though the amount of their fossiliferous contents varies.

A section of the south bank, about two miles and a half below the end of the canal, gave eighteen inches humus and sand over the same depth of indurated yellow sand without fossils, below which are two feet of sandy marl with *Bulla striata*, *Venus cancellata*, and a multitude of *Planorbis* and *Physa;* then three feet of compacter marl with a great many marine fossils and comparatively few fresh-water shells, the deposit containing irregular nodules, lumps and strings of silicified material often extremely hard, and in which the fossils are often represented by mere molds. Below this, which is the chief fossiliferous stratum, lies a foot and a half of sand and marl with few fossils but many fragments, and worn siliceous fragments against which the water washes. This stratum in other places is consolidated to a tolerably compact rock, and the fossil bed above it to a flinty chert. The chert shows manifest indications of having been worn by the action of waves, and one of my specimens shows a boring bivalve still intact in its burrow in one of the protuberances of this layer. In other places fossil oyster-banks could be clearly seen, but nowhere any coral reefs, though isolated heads of coral were

not uncommon. The intermixture of fresh water shells and marine ones, is characteristic of the whole deposit, though the upper stratum contains proportionally many more fresh-water individuals. At the canal, and for some distance below, the beds above described are capped by a very hard Quaternary limestone full of silex and containing only fresh-water shells though occasional intercalated thin layers of marine shells, covered again by fresh water deposits, show that the sea was not far off, and that small alternations of level probably occurred. The same compact limestone, with the same species of *Planorbis*, etc., occurs near Hillsborough, by Tampa, and has been dredged in large masses from the channel by which the harbor of Tampa is entered. This shows a very wide extension of this deposit, the two localities being some ninety miles apart in a direct line.

The marls of the Caloosahatchie contain a large number of species, of which a fair proportion, perhaps one-tenth, are supposed to be extinct; many of the others are known only from deep water. How many of the so-called extinct ones, like *Amusium Mortoni*, will turn out to be still living when the deeper waters of the Floridian coast are thoroughly dredged remains to be seen. A number of the species appear to be more nearly related to shells known from the Asiatic or Californian coasts of the Pacific than to the shells of adjacent waters. But these apparent relations depend a good deal on our ignorance of what the deep waters of the Gulf really contain. In their curious partial silicification these beds afford an interesting parallel to those of Ballast Point, and show that similar chemical action has been going on since Miocene times on this coast.

The age of the Caloosahatchie beds is much the same as others which have been called Pliocene on our Eastern coast. The time has not yet arrived, nor is our knowledge of any part of our later Tertiaries sufficient to enable us to decide finally as to their chronologic relation to each other; except in the most tentative way. But without reference to their place in the system, the geological history of the Caloosahatchie marls is clearly stated in their structure.

The assemblage of species on the whole, in the principal stratum, is such as one might expect to find in water from twenty to fifty feet in depth, judging by what we know of living mollusks. Mixed with these are a certain number of shallow-water forms which may be supposed to have flourished as the water became shoal by elevation of the sea bottom. There were lagoons of fresh water and probably short streams emptying into the sea, and in time of flood sweeping their

fresh-water fauna out on to the shoals, where they died. Part of the bottom became elevated nearly to the surface, oyster banks were formed on it, and the compacter parts became water-worn. Large tortoises wandered there, and occasional mammoths. The absence of shells, like *Litorina* and *Nerita*, seems to indicate that the dry beaches were sandy rather than rocky. In the course of time elevation so shoaled the water that only species like *Venus cancellata* and others able to live between tide marks could remain. Finally the area became cut off almost entirely from the sea and occupied more or less by fresh water ponds in which the pond-snails multiplied in myriads. Drifting sand has buried these and in its turn has been covered with a thin coat of humus in which the pine, palmetto, and a host of scrubby plants make a fairly successful fight against the progress of civilization.

The history of Ballast Point seems to have been much the same in Miocene times, except that there the land seems to have risen sufficiently to enable true air-breathing landsnails to flourish. On the Caloosahatchie they are extremely rare, only one or two specimens having turned up among thousands of fresh-water snails. On the other hand, if Ballast Point rose higher, it was afterward depressed lower, so that several feet of marine orbitolite rock could be formed over it. On the Caloosahatchie the thickness of the marine strata over layers of the fresh water limestone did not exceed six inches.

As it may be supposed that the admixture of fresh water forms with the marine forms has been due to mechanical mixture after fossilization, which in certain places where the marl is penetrated by roots from above, might have occurred, I will add in concluding that the same mixture occurs in the interior of the most flinty chert bowlders. It is curiously paralleled by the mixture I have found in shells collected by the U. S. Fish Commission, in some of the inner lagoons of the Bahamas, where a similar series of geological changes may be supposed to be at this moment in progress. Among the fresh water species is a large *Cyrenella*, a genus recently found by Hemphill in a living state in a South Florida marsh. It has not been before known from the United States, and was originally described from Senegal.

No coral rock or coral reef formation was anywhere observed. The coral-formation observed by Agassiz in the region in the Keys, must be of very limited scope, as it has not been reported from the mainland of Florida by any modern geologist. That the peninsula could not have been formed on the Agassizian hypothesis was pointed out by me in 1882. (Saturday lectures, No. 7, p. 18; Washington, Judd and Detweiler, 1882.)

ART. XX.—*Notes on the Deposition of Scorodite from Arsenical Waters in the Yellowstone National Park;* by ARNOLD HAGUE, of the U. S. Geological Survey.

SCORODITE, although a comparatively rare mineral, is usually found associated with arsenopyrite in several widely separated parts of the world. It occurs in minute orthorhombic crystals in many well-known mining regions and is frequently observed coating crystals of quartz. Hermann mentions an amorphous scorodite from Nertschinsk, Siberia, with nearly the theoretical composition. Quite recently Professor A. H. Chester* has reported its occurrence in the Horn Silver Mine, Utah, where it is observed in thin crystalline crusts and amorphous layers. Crystals of artificially prepared scorodite have been produced by Verneuil and Bourgeois† by submitting metallic iron to the action of arsenic acid in sealed tubes at high temperatures. So far as I know, however, its occurrence as a deposition from thermal mineral springs has never before been noticed.

Scorodite is found in a number of localities in the Yellowstone Park as an incrustation deposited from the waters of several hot springs and geysers. The best occurrence, although the locality is one difficult of access, is at the Joseph's Coat Springs on Broad Creek, east of the Grand Cañon. This group of springs is situated along both sides of the stream bed between rhyolite ridges which rise abruptly for two or three hundred feet. Solfataric action has completely decomposed the rhyolite into smooth, rounded slopes of soft earthy material unsurpassed in beauty of color by any other locality in the Park; orange, yellow, vermilion and white are interblended in a most striking manner. A hundred narrow vents deposit crystals of yellow sulphur far too delicate for transportation. Added to this coloring are the deep greens, reds and yellows derived from the algeous growths lining the hot water channels running off from the numerous springs. Mineral and vegetable colors vie with each other in brilliancy.

On the west side, about 100 feet from the stream and 10 feet above the water, is situated a boiling pool which at the time of my visit, although not seen in action, I regarded as an active geyser. The following accurate description is taken from the note-book of Mr. Walter Weed who accompanied me to the locality: "The water is perfectly clear, deep blue in color, sulphurous in odor, and in constant agitation, bulging and boiling vigorously for about a foot above the level of the pool. The basin measures 10 by 12 feet and is edged and rimmed in by a curious yellow deposit with the hollows and

* This Journal, April, 1887. † Comptes Rendus, vol. xc, 1880.

spaces filled with a deposit of a brilliant green color. The steam is strongly sulphurous and is emitted in large volumes. The overflow is inconsiderable and runs towards the creek in a shallow channel which, near the spring, is lined with the same green coating."

Like all other springs of the group this one issues through fissures in the altered rhyolite, which, around the spring, is everywhere coated with siliceous sinter or geyserite derived directly from the hot waters. Deposited upon the sinter and intermixed with it, occurs the green coating. It lines the basin for about a foot or wherever the spray from the agitated waters falls upon the sides. Analysis shows this mineral to be scorodite, a hydrous arsenate of iron. The layers vary from a mere coating up to an eighth of an inch in thickness. Frequently the cavities and druses in the sinter are filled with scorodite and occasionally it forms nodular masses from a quarter to a half an inch in diameter. Wherever observed it occurs as an amorphous deposit, and when pure, leek green in color. Nitric and sulphuric acids apparently have no action upon the mineral but it is readily attacked by hydrochloric acid.

An analysis made by Mr. J. Edward Whitfield in the chemical laboratory of the Geological Survey, after neglecting a trace of sulphuric acid and a small amount of silica from which it was impossible to free the mineral, shows a nearly pure scorodite, closely agreeing with the theoretical composition. The result of the analysis is as follows:

Fe_2O_3	34·94
As_2O_5	48·79
H_2O	16·27
Total	100·00

Other localities for scorodite are Chrome Springs, at the base of Crater Hills, and one or two places in the Norris Basin. At the Constant Geyser in Norris Basin the water is thrown out two or three times a minute to a height varying from 10 to 20 feet. Around the vents the sinter deposits are finely laminated and show incrustations with greenish tints. Upon breaking off a piece of the sinter and examining a cross-section, thin layers and irregular deposits of scorodite may be observed. The scorodite is already partially altered to limonite and the sinter and pure mineral are more or less discolored by the oxide of iron. It is difficult to obtain a sufficient amount for analysis free from admixture of geyserite and iron oxide. A specimen from the Constant Geyser carrying much silica, yielded Mr. Whitfield as follows:

SiO_2	49·83
Al_2O_3	4·74
Fe_2O_3	18·00
As_2O_5	17·37
H_2O	10·62
Total	100·56

The scorodite, as it is found deposited from these thermal waters, is evidently a very unstable mineral and unless under favorable conditions for its preservation slowly undergoes oxidation, leaving an ochreous material carrying varying amounts of arsenic acid. Alteration into limonite readily occurs and the latter on exposure slowly disintegrates and is mechanically carried away by the action of the running water. Although pure scorodite is only sparingly preserved at a few localities in geyser basins, its identity with the well determined species from Joseph's Coat Springs is clearly made out, as it is easily recognized by the characteristic green color in strong contrast with the white geyserite and the yellow and red oxides of iron.

It may be well to add here that the vegetable green derived from the algeous growths found in nearly all the thermal waters of the Park is not to be mistaken for the mineral green of scorodite. The former is abundant in all hot spring areas, while the latter, a comparatively rare mineral, is obtained only in small quantities after careful search.

During the progress of the work of the Geological Survey in the Yellowstone Park, I have had collected a large number of samples of the thermal waters from the most interesting geysers and hot springs. These have since been subjected to searching analyses by Dr. F. A. Gooch and Mr. J. Edward Whitfield in the chemical laboratory of the Survey and their results which are of great interest will be published at an early date.

Unfortunately no sample of the water from Joseph's Coat Spring was obtained, but a careful analysis was made of the water from the Constant Geyser. This water was collected September 13, 1885; temperature 198° Fahr., the boiling point at this altitude; reaction slightly acid; specific gravity 1·0011.

For the purpose of comparison there is added here the analysis of the water from Old Faithful geyser in the Upper Geyser Basin. Date of collection, September 1, 1884; reaction, alkaline; specific gravity, 1·00096.

The analyses yielded as follows:

	Constant Geyser.		Old Faithful Geyser.	
	Grams per kilogram of water.	Per cent of total material in solution.	Grams per kilogram of water.	Per cent of total material in solution.
Silica	0·4685	28·88	0·3828	27·52
Sulph. acid	0·0923	5·69	0·0152	1·09
Carbonic acid	0·0155	·95	0·0894	6·43
Boracic acid	0·0317	1·95	0·0148	1·07
Arsenious acid	0·0018	·11	0·0021	·15
Chlorine	0·5740	35·39	0·4391	31·57
Bromine	trace		0·0034	·25
Hydr. sulph.	none		0·0002	·01
Oxygen (basic)	0·0185	1·14	0·0419	3·02
Iron	trace		trace	
Aluminium	0·0048	·29	0·0009	·06
Calcium	0·0146	·90	0·0015	·11
Magnesium	0·0018	·11	0·0006	·04
Potassium	0·0745	4·60	0·0267	1·92
Sodium	0·3190	19·67	0·3666	26·36
Lithium	0·0030	·19	0·0056	·40
Ammonium	0·00127	·08	0·00001	
Hydr. (HCl)	0·0008	·05		
Manganese			trace	
Calcium			trace	
Rubidium			trace	
Total	1·62207	100·00	1·39081	100·00
Albuminoid ammonia,	none			0·00002

Thermal waters from the Upper, Lower and Norris Geyser Basins do not differ essentially in their ultimate mineral constituents but show considerable variation in the relative amounts of the salts present. All the waters from the geysers which have been subjected to chemical analysis carry arsenic, the quantity present, according to Gooch and Whitfield, varying from ·02 to ·25 per cent of the mineral matter in solution. That the arsenic of the scorodite is derived from the thermal waters is beyond question, and in my opinion, it is supplied to the waters by the action of superheated steam upon the rhyolite lavas which form the great mass of volcanic rocks of the Park plateau.

While arsenic has been determined in nearly all these waters in no instance has the presence of even a trace of deleterious metal been detected. Arsenical waters of sufficient strength and suitable for medicinal purposes are of rare occurrence. In the United States an undetermined trace of arsenic is reported in the Orkney, Rockbridge Alum, and Roanoke Red Sulphur Springs in Virginia,* and Dr. A. C. Peale informs me that so-

* Mineral Springs in the United States; Dr. A. C. Peale. Bull. 32, U. S. Geol. Surv., p. 64.

dium arseniate has been mentioned recently as occurring in a mineral water in Asche County, North Carolina.

Hygeia Spring, which supplies the bath houses at the hotel in the Lower Geyser Basin, is an alkaline siliceous water carrying ·3 of a grain of sodium arseniate to the gallon. In the amount of sodium arseniate held in solution the Yellowstone Park waters fall below the celebrated arsenical springs of La Bourboule in the volcanic region of the Auvergne, which within recent years have acquired a well deserved reputation for their alterative properties in skin diseases. While the Yellowstone Park waters are somewhat less rich in arsenic than those of La Bourboule they must greatly surpass the latter in their enormous overflow. The entire supply from the springs of La Bourboule amounts to 1500 gallons per minute. During the past season the cauldron of Excelsior Geyser in Midway Basin alone poured into the Firehole river, according to the most accurate measurements which could be made, no less than 4400 gallons of boiling water per minute. According to the analysis of the sample collected August 25, 1884, the water of this geyser contained .19 grains per gallon of sodium arseniate. As yet we know very little about the remedial properties of the Yellowstone waters. At no distant day experience may show that they are decidedly efficacious in external applications and under proper medical guidance may take high rank as arsenical waters for the cure of certain forms of nervous affections and cutaneous eruptions.

Art. XXI.—*The Effect of Magnetization on the Viscosity and the Rigidity of Iron and of Steel;* by C. Barus.

Mr. Herbert Tomlinson* has recently communicated results on the changes of viscosity and of elasticity produced by magnetizing iron. As both classes of data are obtained by the vibration method, it seems not undesirable to attempt to verify them by some static method, and the one described in my last paper† is so easily applicable that I have made use of it. My original purpose was to confine the investigation to measurements of viscosity; but I found in the course of the work that the incidental data on the rigidity of iron and steel could be grouped together. Taken collectively in this way, they led to inferences which the well-known and comprehensive researches

* Tomlinson: Beiblätter No. 3, p. 176, 1887; original in Proc. Roy. Soc., xl, p. 447, 1886, is unfortunately not at my disposal.

† This Journal, xxxiv, pp. 1 to 4, 1887. In equation (1), p. 1, of this article ψ is obviously to be replaced by $d\psi$.

of Wiedemann* insufficiently emphasize. I refer to the effect of magnetization on the rigidity of iron and steel, as modified by the dimensions of the metal temporarily strained. I shall show that the increment of rigidity due to magnetization increases at an accelerated rate as the soft, temporarily twisted wire becomes more nearly filimentary. Now, since the said increment is *independent* of the sign of the current in the helix, and moreover increases with the current intensity in a way which I have found not seriously irregular, it seems profitable to attempt to utilize this principle for the construction of electric dynamometers.† This is the point of view from which much of the present paper has been written. It also contains a series of results on the rigidity of magnetized steel temporarily strained and varying in temper from extreme hard to extreme soft.

Viscosity of Magnetized Steel and Iron.

Apparatus and method.—To make the present measurements it is merely necessary to replace the heating apparatus described in the former paper by an appropriate helix. The two wires to be examined are in the same vertical line, separated by a rigid piece of brass which carries the index mirror. Any desirable rate of twist may be imparted by rotating and then fastening either the upper or the lower end of the system. If both ends be rotated symmetrically in opposite directions, the mirror remains stationary. In this way any reasonable amount of twist may be stored without moving the image of the scale out of the field of the telescope.

The wires of the system were identical as regards length, diameter, and composition; and the arrangement adopted was such that at any time the upper wire might be under the influence of a powerful magnetic field. The helix used for this purpose consisted of ten layers of 230 turns each, doubly wound in such a way as to form two independent partial helices of 115 turns of wire for each layer. For the same current the fields of these partial helices were identical; by connecting them, either differentially or in series, the field obtained was either zero or the maximum for the given conditions. The length of the helix being 20^{cm}, its internal radius $1{\cdot}25^{cm}$, its external radius $2{\cdot}07^{cm}$, the magnetizing force at the center proves to be 1425 c. g. s. units of intensity per c. g. s. unit of current or 142·5

* Wiedemann: Pogg. Ann., ciii, p. 571, 1858; ibid., cvi, p. 161, 1859; Galvanismus, 3d ed., 1883, III, p. 683–698. Less closely allied researches on the effect of magnetization on torsion, etc., are due to Matteuci: C. R., p. 301, 1847, and to Wertheim: C. R., xxxv, p. 702, 1852, as well as to Wiedemann (l. c.), and more lately to Ewing (Proc. Roy. Soc., No. 228, p. 117, 1883).

† Cf. page 177.

($g^{\frac{1}{2}}/c^{\frac{1}{2}}s$) per Ampère. Current was obtained from five flat Grove cells, in mean intensity of about one Ampère. Hence the iron wires were probably not far from saturation, supposing that a field of 140 c. g. s. units of intensity is sufficient to magnetically saturate soft iron.

Without elaborate precautions it is impossible to produce a strong field for great lengths of time in this way, without perceptibly heating the helix. This introduces a serious error, for the viscous detorsion actually observed is due to a heat effect superimposed on a magnetic effect, both of which are of the same order of minuteness. By using a helix like the one above, in which current may be passed through the two partial coils in the same or in opposite directions, the full heat effect may be observed either with or without the magnetic effect. For when the coils are joined differentially the field produced is zero, whereas the heat generated in the helix is (cæt. par.) not changed in amount. This is the way in which I endeavored to eliminate the temperature discrepancy.

It is difficult to find two wires which are absolutely identical; after softening some parts of a wire yield more easily to stress than other parts. It is not until the less rigid parts have been stiffened by receiving permanent set that the rate of twist temporarily stored is the same throughout the length of the wire. All viscous motion which is due to differences in the mechanical or chemical properties of the metals may be detected by allowing series of observations for open circuit to alternate with similar series for closed circuit.

Results.—Table 1 contains results as obtained with steel annealed about midway between soft and hard. Here t is the temperature of the helix and of the upper wire, t' the temperature of the lower wire, l and ρ the length and radius of each. φ denotes the amount of viscous detorsion per centimeter per wire (i. e., per two centimeters of the system), in radians at the time h in hours; τ denotes the rate of twist in degrees imparted to the system at the unmagnetic end. If φ increases or decreases according as the sign of the twist is positive or negative, then the unmagnetic wire is of greater viscosity than the magnetic wire; and vice versa. Intervals of observation corresponding to open and closed circuits are appropriately indicated. Whenever the circuit is closed differentially in the helix so as to produce a zero magnetic field, this is also stated. φ is correct to 3 or 4 units of the last place.

The three parts of this table show that the viscous differences in question are invariably minute. In part first the originally less viscous lower wire becomes perceptibly more viscous when the circuit is closed around the upper wire. The apparent

effect of magnetization is here a decrement of viscosity. In the second part the wires for open circuit are equally viscous; for closed circuit the results are the same as in part first both as regards sign and amount. The apparent effect of magnetization is again a decrement of viscosity. Part third, finally, contains the interpretation of these results: it is seen that results of the same magnitude and character are obtained when the magnetic field due to the helix (other effects remaining the same) is zero. The viscous effects here observed are therefore wholly due to temperature, and it may be safely inferred that magnetized and unmagnetized steel differ in viscosity by an amount less than is produced by 5° difference of temperature.

TABLE 1.

Viscosity of steel, annealed 360°. $l=30^{cm}$; $2\rho=0{\cdot}083^{cm}$; $t'=20°$.

h	$\phi\times10^6$	t	Remarks.	h	$\phi\times10^6$	t	Remarks.
hours.	radians.	°C.		hours.	radians.	°C.	
0·00	− 0	..		1·10	−21	..	
2·67	−33	..	Circuit open. $\tau=+6°$.	1·12	−10	19	
4·33	−35	..		1·40	−23	23	
24·00	−50	..		1·67	−23	25	Circuit closed. $\tau=-6°$.
25·42	−50	..		1·92	−34	27	
25·60	−35	..		2·08	−38	..	
25·67	−15	..		2·40	−42	28	
25·83	− 3	..	Circuit closed. $\tau=+6°$.	2·80	−49	29	
26·00	+ 7	..		0·00	− 0	17	
26·25	+10	..		0·18	−30	21	Circuit closed; field zero. $\tau=-6°$.
26·75	+15	..		0·43	−46	26	
0·00	− 0	..	Circ't open. $\tau=-6°$.	0·60	−53	28	
1·00	− 3	..		0·85	−58	29	
				1·00	−63	30	
				4·52	− 7	..	Circ't open. $\tau=-6°$.
				23·25	−17	..	

Inasmuch as the steel wire of table 1st is permanently a magnet after the first induction, sharper results may be looked for in experimenting with iron. As regards viscosity, iron is less susceptible to the influence of temperature than either annealed steel or even soft steel; it is more magnetically permeable and it loses its magnetization completely when slightly jarred in a zero field.

Table 2 contains results for soft iron. The arrangement being identical in plan with table 1.

In the first part of table 2, φ increases whenever both wires are unmagnetic and decreases at a gradually diminishing rate whenever the upper wire is magnetic. The apparent effect of magnetization is therefore a diminution of viscosity, a result in accordance with the inferences from table 1. To interpret this apparent result the second part of table 2 is available. It

shows that when the current is passed through the helix differentially, φ increases at the same rate as before, notwithstanding the fact that the field is now zero. Hence the amount of viscous detorsion observed is a temperature discrepancy and no viscous effect due to magnetization is discernible.

TABLE 2.

Viscosity of magnetized iron. Rods Nos. 7, 8, annealed soft. $l=30^{cm}$; $2\rho=0{\cdot}110^{cm}$; $t'=20°$; $\tau=-3{\cdot}6°$.

h	$\phi\times10^6$	t	Circuit.	h	$\phi\times10^6$	t	Circuit.
0·00	0	--	Open.	3·48	+15	26	Closed.
0·57	− 3	--		3·68	+ 4	30	
0·58	+65	--	Closed.	4·05	− 5	34	
0·92	30	33		4·05	−72	34	Open.
1·23	8	34		4·47	−62	29	
1·23	−58	33	Open.	4·52	−55	--	Closed differentially; magnetic field zero.
1·80	−53	28		4·75	−65	32	
1·85	+18	--	Closed.	4·92	−63	33	
2·00	+10	29		5·07	−70	34	
2·17	0	33		5·38	−73	--	
2·48	− 3	34	Open.	5·56	−73	--	Open.
2·50	−71	34		22·30	−50	--	
2·97	−60	29					
3·47	−52	26					

In table 3, I give similar results with a thinner wire.

TABLE 3.

Viscosity of magnetized iron. $l=30^{cm}$; $2\rho=0{\cdot}083^{cm}$; $t'=20°$; $\tau=-3°$.

h	$\phi\times10^6$	t	Circuit.	h	$\phi\times10^6$	t	Circuit.
0·00	0	--	Open.	5·13	310	--	Open.
0·38	80	--		5·57	328	25	
0·42	189	21	Closed.	23·00	545	18	Closed.
0·50	195	21		23·10	653	--	
0·75	220	26		23·33	645	--	
1·05	245	29		23·67	643	28	
1·38	265	30		24·00	645	30	
1·42	161	30	Open.	24·05	538	30	Open.
1·68	183	28		24·42	550	26	
1·95	203	25		24·95	560	23	
2·17	218	23		24·97	670	--	Closed.
2·18	328	24	Closed.	25·33	660	28	
2·48	334	27		26·17	668	32	
2·88	348	30		26·20	561	--	Open.
3·23	360	32		27·12	580	23	
3·25	255	--	Open.	27·27	690	--	Closed.
3·50	270	--		28·28	685	31	
4·17	298	--	Closed.	28·35	580	--	Open.
4·20	407	--		48·00	740	--	
4·67	410	28					
5·08	420	30					

In these results the thermal and magnetic effects are superimposed on the continuous viscous motion due to inequalities in the wires, the upper wire being more viscous than the lower wire. In every case, however, this normal viscous detorsion is perceptibly retarded whenever the upper wire is magnetized. It follows conformably with the above results that the viscosity of iron is apparently diminished by magnetization; that the amount of this diminution is no larger than is quite in keeping with the heating effects due to the passage of current through the helix. My results therefore fail to give any satisfactory proof that magnetized and unmagnetized iron differ in viscosity by more than the equivalent of one or two degrees centigrade, at ordinary temperatures.

I am far from wishing to assert, however, that Tomlinson's results are temperature phenomena. It is possible that the marked tendency of soft iron to assume permanent set, and consequently the relatively large viscous motion immediately after strain is imparted, makes the vibration method particularly sensitive in registering the viscous effect of magnetizing iron.* But by using static methods and observing in the interval of *gradual* or *purely viscous* deformation, no satisfactory evidence of such an effect is discernible. Moreover, magnetization changes the rigidity of iron and therefore necessarily jars a twisted wire. There result such changes of viscosity as are produced by any sudden vibratory disturbance; changes which of course are purely mechanical, but which obscure the direct result of magnetic induction beyond recognition.

RIGIDITY OF MAGNETIZED IRON AND STEEL.

Iron.—The effect of longitudinal magnetization on iron or steel twisted within the elastic limits is marked detorsion, increasing in amount with the intensity of magnetic field, increasing also with the rate of twist, at a retarded rate in both instances, toward a maximum. If the sense of the magnetization be reversed (i. e., if the helix current be changed in direction) the amount of detorsion is in general unchanged.†

In tables 1, 2, 3, discontinuous but perfectly regular variation of φ, on passing from unmagnetized to magnetized iron or steel are strikingly apparent. Table 4 contains special results for large rates of twist (τ), and has been drawn up to exhibit the independence of φ of any possible irregularities in the position of the helix as well as the change of sign of φ with the sign of τ. The table shows also that the sign of φ is

* Cf., moreover, Wiedemann's remarks on the vibration method, Wied. Ann., vi, 485, 1879.

† The above phenomena have been elaborately discussed by Wiedemann (Galvanismus, pp. 683–698).

reversed when the helix is passed from the upper to the lower wire. It follows, therefore, that φ is not influenced by errors which in my apparatus might result from the increase of length due to magnetization. In other words, in the mechanism adopted magnetic elongation has no rotational effect. l and ρ denote length and radius each in centimeters. τ is in degrees, φ in radians, as above.

TABLE 4.

Showing the effect of sign of twist and of position of helix.

REMARKS.	No.	τ	$\phi \times 10^6$
Helix symmetrically on upper wire	17, 18	+6	−130
	$2\rho=0{\cdot}053^{cm}$	−4·5	+133
	$l=30^{cm}$	+6	−139
Helix symmetrically, on *upper* wire	19, 20	−3·0	+93
" +eccentrically, " "	$2\rho=0{\cdot}083^{cm}$	−3·0	95
" −eccentrically, " "	$l=30^{cm}$	−3·0	93
" +diagonally, " "		−3·0	95
" −diagonally, " "		−3·0	95
" high position, " "		−3·0	94
" low position, " "		−3·0	97
" symmetrically, on *lower* wire		−3·0	88
Helix, symmetrically, on upper wire	15, 16	−3·0	+66
	$2\rho=0{\cdot}110^{cm}$	+3·0	−68
	$l=30^{cm}$		

These sudden changes in the values of φ due to magnetization are equivalent to an increase of the rigidity* of steel and I shall therefore describe them as such. If T be the torsional rigidity of a wire, i. e., the reciprocal of the amount of twist per unit length per unit moment of twisting couple; and if G be the absolute rigidity of the material, i. e., the reciprocal of the amount of shear per unit of shearing force, then

$$G=\frac{2T}{\pi\rho^4}.$$

Now if in the present apparatus τ' be the rate of twist in radians and φ the change of τ' due to magnetization; if moreover G_m and G be the rigidities of the magnetized and unmagnetized wires respectively; then since the radii (ρ) are identical

$$G_m\,(\tau'-\varphi)=G\,(\tau'+\varphi),$$

which if φ is small in comparison with τ' may be written

$$\frac{G_m}{G}=1+\frac{2\varphi}{\tau'}=1+\mu.$$

* The retrograde motion formerly observed when the upper wire heated to a high temperature (100°−300°), is cooled to the temperature of the lower wire (this Journal, xxxiv, p. 17), might in like manner be used to compute the variations of rigidity due to temperature. In such a case, however, the variations of temperature from the high value to the low value must be as nearly instantaneous as possible, otherwise elastic and viscous detorsions will be erroneously confounded.

A final datum of interest is the *obliquity*, ω, of the external fibre, or the angle in radians between the axis of the wire and any tangent of the helix into which a straight surface fiber, or generatrix has been twisted. This is approximately

$$\omega = \frac{\pi\rho}{180}\tau,$$

τ being the rate of twist in degrees. This variable ω is intended to have no more than geometrical significance. It is known that on twisting and again untwisting an iron wire beyond the elastic limits, the fibers do not return upon themselves to their original forms and positions, but that they become irregularly sinuous lines.

TABLE 5.

Showing the effect of magnetization on the rigidity of soft iron. l=30^{cm}.

τ	Nos. 1. 2. 2ρ=0·234			Nos. 3, 4. 2ρ=0·136			Nos. 5, 6. 2ρ=0·090			Nos. 7, 8. 2ρ=0·110			Nos. 9, 10. 2ρ=0·070			Nos. 11, 12. 2ρ=0·048			Nos. 13, 14. 2ρ=0·022		
	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$	$10^3\times 3$	$10^6\times\varphi$	$10^3\times\mu$
°																					
−0·43	0·8	12	3·2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
−0·75	1·5	18	2·7	0·9	24	3·7	0·6	42	6·4	0·7	34	5·2	0·5	37	5·6	0·3	60	9·2	..	..	..
−1·12	2·3	23	2·3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
−1·50	3·1	30	2·3	1·8	43	3·3	1·2	68	5·2	1·4	54	4·1	0·9	82	6·3	0·6	107	8·2	..	..	..
−2·25				2·7	49	2·5	1·8	75	3·8	2·2	62	3·2	..	..	..	0·9	116	5·9	..	..	..
−3·00				3·6	51	2·0	2·3	78	3·0	2·9	65	2·5	1·8	95	3·6	1·2	131	5·0	0·6	86	3·3
−3·75							..	..	..	3·2	66	2·0	..	..	..	..	..	..	..	..	..
−4·50							3·5	77	2·0				2·7	104	2·7	1·9	148	3·8	..	..	..
−5·25													3·2	103	2·3	..	..	..	..	..	..
−6·00																2·5	156	3·0	1·2	166	3·2
−7·50																3·1	148	2·3	..	..	..
−9·00																			1·7	205	2·6
−12·50																			2·4	220	2·0
−15·00																			2·9	237	1·8

In table 5, I have given values for these variables as obtained with soft iron wires of different thicknesses. The intensity of magnetic field has been stated above (p. 177). Commencing at low values, the rate of twist (τ) is successively increased to the maximum value, which can be imparted, i. e., until, with the occurrence of marked permanent set, the limits of resilience of soft iron are fully reached. After this it was usual to twist the wires further, imparting several thousand degrees of permanent set, whereupon τ was decreased from the maximum to zero. In the table, ω, φ, μ, are means of the values obtained by thus successively increasing and decreasing τ. As before ρ is the radius and l the length of the wires, of which Nos. 1, 2, 3, 4, 5, 6 were drawn down from a single piece of wire, Nos.

7, 8, 9, 10, 11, 12 from a second piece of wire, Nos. 15, 16, 17, 18 from a third piece of wire. Comparison of data is to be made only for wires drawn to different diameters from the same sample of iron.* All wires are annealed at red heat in air.

To this may be added the following data for soft iron filaments drawn from the same wire. ω is the maximum.

No.	2ρ	$\omega \times 10^3$	$\phi \times 10^6$	$\mu \times 10^3$
15, 16	0·032	2·9	212	2·4
17, 18	0·025	2·8	241	2·3

It has been stated that the wires to which table 5 refers were all soft. Their diameters vary over the very large interval $0{\cdot}022^{cm}$ to $0{\cdot}234^{cm}$, and the rates of stored twist from 0·4° to 15°. Nevertheless the maximum obliquity, ω, of the external fiber is nearly the same for all the rods. In other words, the limits of torsional resilience of soft iron are reached when the obliquity of the external fiber exceeds 0·0032 radians.† After this, iron yields to the torsional couple and the result is indefinite permanent set.

Inasmuch therefore as ω is comprehended within about the same interval (0 to 0·003) for all the wires irrespective of thickness, it is expedient to discuss the variation of φ (p. 177) with reference to ω. Indeed the diagram of φ as a function of ω shows the characteristic family of curves with remarkable terseness. φ increases with ω at a rate which is greater in proportion as the thickness of the wires, 2ρ, diminishes, and which decreases and finally approaches zero when ω is a maximum. The detorsion due to magnetization ceases to increase when the sections of the rod slide on each other. Indefinite twisting beyond the elastic limits has no effect so long as the wire is not appreciably hardened. But it is the dependence of φ on ρ to which I desire principally to advert. The following series of values obtain for $\omega = 0{\cdot}003$.

* Imperfections in the wire plate prevented me from drawing all the wires from a single sample of iron.

† The literature on torsional strains is so voluminous that I can scarcely suppose similar simplifying observations have not been made. But I have found none. Permanent and temporary torsions have been compared with regard to their relations to stress, to the mechanical condition of the material carrying stress, etc., by Wertheim (Comptes Rend., xl, p. 411, 1855; Ann. de Chim. (3), l, p. 195, 1857); more elaborately even by Wiedemann (Wied. Ann. vi, p. 485, 1879; ibid. vii, p. 496, 1879; Phil. Mag. (5), ix, pp. 1, 97, 1880), and by Perard, (Revue univ. d. Mines, 1879). Reference is also to be made to Tresca (C. R., lxxiii, p. 1104, 1871), to De Saint-Venant, who has investigated the mechanics of ductile substances, and to others. In Wiedemann's last research, correlated values of temporary and permanent torsions are discussed both as they exist immediately after imparting strain and as they exist after an indefinite lapse of time. I have no such comprehensive purpose in view; nevertheless the great convenience of the variable ω is obvious from the way in which I am able to use it.

$2\rho\times10^3=$	234	136	110	90	70	48	22
$\varphi\times10^6=$	30	50	65	80	105	150	240

to which add the values on page 183.

The accelerated rate of increase of φ with ρ as exhibited by these data has suggested the remarks already made, viz: since φ is independent of the sign of the current in the helix it is probable that ρ may be taken sufficiently small to render these phenomena practically available for the measurement of induced or alternating currents. The actual deflection increases with the length of the iron wire. It would be expedient therefore to suspend a light mirror bifilarly from very long filaments of iron and of glass or metal, surrounded by a long cylindrical helix.* The rate of twist temporarily stored in the soft iron filament is the maximum within the elastic limits. I give the following example of deflections produced by the current of an ordinary induction coil, acting on a relatively thick and short iron wire.† The currents are alternately off and on. The two series were made about an hour apart.

Nos. 5, 6; $2\rho=0{\cdot}090^{cm}$; $l=30^{cm}$; deflection=

30	75	40	80	40	83	40	$\varphi=20\times10^{-6}$
52	85	40	75	35	73	35	$\varphi=19\times10^{-6}$

In so thick a wire the heat effect of alternating magnetizations soon becomes apparent. The result is temporary diminution of the rigidity of the wire. Much better results are already apparent when the above thin wires are used. For instance, (same coil),

Nos. 15, 16; $2\rho=0{\cdot}034^{cm}$; $l=30^{cm}$; deflections=

50	180	50	200	70	190	70;	$\varphi=65\times10^{-6}$
70	200	60	200	65	200	60;	$\varphi=69\times10^{-6}$

Further discussion of these results (the errors of which are largely due to the apparatus) is not now expedient.

The values of φ in table 5 are means of five observations with the circuit alternately made and broken. A small amount of permanent detorsion is always imparted to the wire after the magnetism has disappeared, as Wiedemann‡ first pointed

* It is needless to state that I am well aware of the difficulties here in the way, difficulties which Wiedemann has so carefully digested. In my apparatus, however, all pivot and pulley rotations are avoided. I have also repeated the results relating to fine wires at length with very light mirrors, by which no errors due to an asymmetrical mirror adjustments are encountered. The very small couples which come into play in operating with filamentary wires often make damping by submerged vanes objectionable. I have therefore often discarded them.

† The wire plates at my disposal were such that $2\rho=0{\cdot}02$ was the smallest diameter obtainable. But the above series of results are fully sufficient and sufficiently in accordance to justify the inferences drawn.

‡ Wiedemann: Galvanismus, p. 689.

out. The following example may be given from very many results of my own. In the case of Nos. 3, 4, the scale readings for currents alternately off and on, were

$\tau=$	0·7°	1·5°	2·3°	2·2°	1·5°	0·7°
(off)	130	110	90	80	50	60
(on)	150	200	185	180	128	100
(off)	80	85	70	70	38	58
(on)	160	188	180	178	130	100
(off)	80	82	70	72	40	60

This is very perceptible in the first part of the measurements where τ or ω increase from zero to the maximum; it generally becomes smaller in amount when ω decreases from the maximum to zero. The method of varying ω from 0 to the high value and then from the high value to zero leads to a cycle of results. In the case of Nos. 7, 8, for instance

$\omega\times10^3=$	0·0	0·7	1·4	2·2	2·9	3·2	ω increasing.
$\varphi\times10^6=$	5	40	57	63	66	65	
$\omega\times10^3$	3·2	2·9	2·2	1·4	0·7	0·0	ω decreasing.
$\varphi\times10^6$	67	64	61	51	28	3	

Observation, which might perhaps be grouped with Mr. Ewing's* phenomena. But in some of the many other like experiments which I made there is an element of vagueness.

Table 5 shows finally that the influence of magnetism on the rigidity of soft iron is greatest when ω is zero. It is obvious since φ increases at a retarded rate while τ or ω increase uniformly, that μ must continually decrease. The large values of μ differ considerably being greater as a rule for smaller diameters. The minimum values of μ obtained are of about the same magnitude, $\mu=0{\cdot}0021$. If the conditions of indefinite permanent set are such that the obliquity of the external fiber, attain a fixed value, then these conditions imply that the rigidity of steel is changed by magnetization by a fixed minimum amount.

Steel.—In the following table 6, I give the values of φ which hold for steel for the large rate of twist $\tau=6°$. The wires are carefully annealed as described elsewhere. Diameter $2\rho=0{\cdot}083^{cm}$. A soft iron wire for which maximum ω is only 0·0021 is also tested for comparison.

The curious result of this table is this, that during the first phase† of annealing, the effect of magnetization on the rigidity of steel is almost nil. This effect becomes of marked impor-

* Ewing: Trans. Roy. Soc., ii, 1885, p. 523–4.

† This Journal, xxxi, p. 443, 1886.

TABLE 6.

Rigidity of magnetized Stubs' steel. $\omega = 0{\cdot}0043$.

TEMPER.	$\phi \times 10^6$	$\mu \times 10^3$
Glass-hard	3	0·06
Annealed 100°	4	0·08
" 190°	4	0·08
" 360°	22	0·42
" 450°	25	0·48
Soft steel	41	0·78
Soft iron	95	3·63

tance during the second phase.* In other words, if we suppose the wire to pass continuously from hard to soft, *the increase of the magnetic coefficient of rigidity, μ, is particularly pronounced after the variations of the thermo-electric, the galvanic and the viscous properties of steel have practically subsided.* μ therefore shows close affinities to the induced and to the residual magnetization of an iron-carburet. Agreeing with Wiedemann's results, μ is invariably smaller for steel than for iron. In general if μ be regarded in its dependence both on ω and on hardness, it appears that the increment of rigidity of an iron-carburet produced by magnetization is greater in proportion as the metal shows greater tendency to assume permanent set—a result which applies for iron and for steel.

Lab. U. S. G. S., Washington, May, 1887.

* In a letter to the Journal (xxxiii, p. 308), Prof. W. F. Barrett has taken exception to certain remarks made by Dr. Strouhal and myself (this Journal, xxxiii, p. 35) on phenomena more or less connected with the second phase of annealing. We regret exceedingly to have overlooked Prof. Barrett's papers. Our object, however, was only to give an enumeration of such observations as had occurred to us *incidentally*. Of Gore's discovery we were aware, and the statement is thus made in the text and in U. S. G. S., Bull. 14. Owing to a misconstruction of the foot-note in the Journal (l. c., p. 35, ‡), "ibid." happens to refer to "Wied. Ann." instead of to "Phil. Mag." The reference is otherwise correct.

We avail ourselves of the present opportunity to state that in Prof. J. A. Ewing's paper on the "effects of stress and magnetization on the thermo-electric quality of iron" (Phil. Trans., II, p. 361, 1886) mention is made of our results only in a final note dated Sept. 17, 1886. Our work was accessibly published much earlier (Wied. Ann., xiv, p. 54, 1881; cf. also ibid., vii, p. 408, 1879). We believe we were the first to actually measure Thomson's thermo-electric effect of magnetization as well as to point out its probable relations to the strain of a magnetized rod.

ART. XXII.—*Fauna of the "Upper Taconic" of Emmons, in Washington County, N. Y.* With Plate I. By CHARLES D. WALCOTT.

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IN his second memoir on the "Taconic System,"* Dr. Emmons described two species of trilobites from the black Taconic slate near Bald Mountain, Washington County, N. Y.; *Atops trilineatus* and *Elliptocephala asaphoides.* Subsequently the black slate was referred to the upper division of the Taconic and with it the contained fossils. It is the fauna of which these two species form a part that is embraced within the title of this paper.

From the time of the original discovery and description of the fossils by Dr. Emmons, up to the present, no discovery of Cambrian or First Fauna fossils has been reported from Washington County, except in 1886, when the discovery of Cambrian fossils at Granville was made known.†

At an horizon in Georgia, Vermont, equivalent to that of the "Upper Taconic" series, fossils were found by Noah Parker, Esq., and given to Rev. Z. Thompson, who sent them to Professor Hall who, in 1859, described and referred them to the Hudson River shales (Twelfth Ann. Rep. State Cab. Nat. Hist., 1859). Subsequently, this reference was changed to the Quebec group (Thirteenth Rep., *idem*, 1860), by Professor Hall, and in 1861 (Geol. Surv. Canada; New Species Lower Silurian Fossils, by E. Billings, p. 1, 1861), they were referred to the "Potsdam Group (Primordial Zone)," by Mr. E. Billings. Subsequently Mr. S. W. Ford discovered an equivalent fauna in the vicinity of Troy, N. Y., and concurred with Mr. Billings in referring it to the Lower Potsdam (this Journal III, vol. ii, p. 34, 1871). Afterwards Mr. Ford discovered that the fauna extended farther south and into Columbia County, N. Y.

In the introduction to Bulletin 30, of the U. S. Geological Survey, I have given a summary of our knowledge of this fauna (Taconic or Middle Cambrian) as known to date of publication (1886), and to that I will now add the results of my study of the fauna of the typical "Upper Taconic" area and section in Washington County, N. Y.

* Pamphlet, 1844, reprinted in Agric. N. Y., vol. i, pp. 64, 65, 1876.

† Proc. Amer. Assoc. Adv. Sci., advance sheet, December, 1886; Cambrian Age of the Roofing Slate of Granville, Washington County, N. Y.; Charles D. Walcott.

‡ In a paper read by the writer before the National Academy of Sciences, April 22, 1887, the name Taconic is restricted to the Middle Division of the Cambrian. This paper, with map and sections, will be published within a short time.

Thirty-five species and one variety were found in the even-bedded and conglomerate limestones and the associated slaty argillaceous and siliceous shales. Of these eleven species and one variety were unknown before and are described in this paper. The geographic distribution of the others is given in Bulletin 30, with the exception of their occurrence in Washington County.

The following is a list of the species now in the collections of the U. S. Geological Survey, from Washington County:

Protospongia (loose spiculae).
Ethmophyllum (fragment).
Lingulella cælata Hall (sp.).
Lingulella Granvillensis, n. sp.
Lingulella, sp. undet.
Linnarssonia Taconica, n. sp.
Kutorgina pannula White (sp.).
Obolella, sp. undet.
Orthis, sp. undet.
Orthis Salemensis, n. sp.
Camarella, sp.?
Fordilla Troyensis Barrande.
Modiolopsis (??) prisca, n. sp.
Platyceras primævum Billings.
Hyolithes Americanus Billings.
Hyolithes communis Billings.
Hyolithes impar Ford.
Hyolithellus micans Billings.
Hyolithellus micans var. rugosa, n. var.
Stenotheca elongata Walcott.
Stenotheca rugosa Hall (sp.).
Aristozoe rotundata, n. sp.
Aristozoe Troyensis Ford.
Leperditia (I) *dermatoides*, n. sp.
Microdiscus connexus, n. sp.
Microdiscus lobatus Hall (sp.).
Microdiscus speciosus Ford.
Olenellus asaphoides Emmons.
Olenoides Fordi, n. sp.
Solenopleura (?) *Nana* Ford.
Solenopleura (?) *tumida*, n. sp.
Conocorphye trilineata Emmons.
Ptychoparia, like *P. Adamsi*.
Ptychoparia (?) *Fitchi*, n. sp.
Ptychoparia, sp. undet.
Ptychoparia (?) *clavata*, n. sp.

Of the above, *Lingulella Granvillensis*, *Linnarssonia Taconica*, *Microdiscus connexus* and *Conocoryphe trilineata* are types related more closely to the Lower Cambrian than to the Middle Cambrian fauna. Stratigraphically, they occur low down in the section, and I shall not be surprised if other representative species and some species identical with those from the Lower Cambrian of St. John, N. B., or Newfoundland, are found at about the same horizon.

I have discussed the distribution of the Middle Cambrian or Taconic fauna in Bulletin 30, and the reader is referred to that report for further information.

In a report on the Geology of Washington County, now in the course of preparation, a geologic map will show the distribution of the formations and the localities of the fossils and the vertical range of the latter will be given in the sections.

Lingulella Granvillensis, n. sp.

Plate I, figs. 15–15c.

Shell small, elongate ovate, margins sub-parallel for a short distance at the widest portion about midway of the shell, broadly rounded in front, ventral valve attenuate toward the beak; dorsal valve ovate and rounded at the beak. General

surface depressed convex. Surface marked by fine concentric lines and more rarely, fine radiating lines.

The cast of the interior of the ventral valve shows four narrow elongate scars, radiating from the beak toward the front margin.

A cast of the interior of a dorsal valve shows fine vascular markings and a well-marked median groove, also faint impressions of the anterior adductor muscular scars and, also, what may have been the adjustor muscular scars.

This species is the representative, in the Middle Cambrian of *Lingulella Dawsoni* (Bull. 10, U. S. Geol. Survey, p. 15, 1884), of the St. John formation of the Lower Cambrian. It may also be compared with *Lingulella ferruginea*, which ranges from the Harlech beds through the Menevian and probably into the period of the Lingula flags (Brit. Foss. Brach., vol. iii, p. 337). Dr. G. Linnarsson figures a closely related species from the Paradoxides beds of Sweden (Brach. Par. Beds of Sweden, pl. III, figs. 24–28).

Formation and Localities.—Cambrian. Limestones interbedded in the Taconic shaly slates; two miles south of North Granville; by the roadside a little west of the bridge crossing the Poultney River at Low Hampton; and on the roadside north of school house No. 4, in the northeast part of Whitehall, Washington County, N. Y.

Linnarssonia Taconica, n. sp.

Plate I, figs. 18–18d.

Shell small, rarely exceeding 3^{mm} in length or breadth, usually circular to transversely broad oval. Ventral valve moderately convex; apex excentric; dorsal valve depressed convex; beak obtusely pointed, marginal; surface of the valves marked by fine lines of growth.

In the interior of the ventral valve, near the posterior margin, oblique scars occur, one on each side of the raised rim surrounding the foraminal opening in allied species. From a point of the foraminal rim a narrow depression extends obliquely outward and forward, on each side, so as to enclose a ^ shaped elevation, that is strongly marked in casts of the interior of the valve. The interior of the dorsal valve shows two large oval scars, near the posterior margin, separated by a low ridge that extends over three-fourths of the distance to the front margin.

This species is related to both *L. transversa* and *L. sagittalis*.* It differs chiefly in the characters of the interior of the dorsal valves. As yet none of the specimens have shown the ventral

* This Journal, III, vol. ix, pp. 114–117.

valve to be perforate, this is owing probably to the minute size of the opening and the imperfection of the specimens which have been examined.

This is the first instance known to me of the occurrence of this genus in association with the Taconic or Middle Cambrian faunas, as it is essentially a Lower Cambrian type both in New Brunswick, Newfoundland, and Sweden and Wales.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates, at Rock Hill school house (No. 8), near North Greenwich; 1½ miles east of North Greenwich; lowest fossiliferous horizon on D. W. Reid's farm, 1½ miles west of North Greenwich; west summit of Bald Mountain, in the town of Greenwich; two miles south of North Granville; on the roadside just west of Low Hampton crossing of the Poultney River; and one mile south of Shushan, all in Washington County, N. Y.

Kutorgina pannula White, (sp.).

Plate I, figs. 14–14b.

Kutorgina pannula.—See Bull. 30, U. S. Geol. Survey, p. 105, 1886.

The specimens of this species, from Washington County, are hardly distinguishable from those obtained on the slopes of the Highland range in southern-central Nevada. In Nevada, the species occurs at the lowest known fossiliferous horizon and ranges up through 1400 feet of strata, but not into the Upper Cambrian or Potsdam horizon.

The edges of the reticulations on the surface of the New York specimens are usually sharper than those of the Nevada form, but I do not think that the difference is of specific importance.

Its occurrence, in Washington County, in the lower beds of the Taconic formation, is of great interest, as it adds another connecting link between the widely separated localities of this fauna in Nevada and New York.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates, on the roadside, just west of Low Hampton crossing of the Poultney river and two miles south of North Granville, Washington County, N. Y.

Orthis Salemensis, n. sp.

Plate I, figs. 17–17*a*.

Shell about the average size of the Cambrian species of the genus. Transversely subquadrilateral; front broadly rounded and slightly sinuate midway: hinge line as long as the greatest width of the shell.

Ventral valve convex, most elevated about one-fourth the distance from the beak to the anterior margin; beak small and incurved to the margin of the medium sized area; the surface of the area and the foramen have not been observed; mesial sinus broad and shallow, it is marked by a low median rib and, laterally, by two costæ on each side, a third appearing just outside the sinus.

The dorsal valve, associated in the same hand specimen of limestone, is slightly more convex; frontal margin with a rather deep sinuosity to receive the projection of the ventral valve; median fold broad and but slightly elevated, marked by two or three low costæ; the beak appears in the broken specimen in the collection to be scarcely elevated above the surface of the shell, and to terminate at the cardinal margin; area unknown.

The surface of both valves is marked by fine concentric lines of growth, and low, rounded costæ, varying in number from six to seven, as in the specimens figured, to twelve or fourteen in other specimens.

In the broad costæ and the general aspect of the shell this species is unlike any known to me from the Cambrian.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates, one and one-half miles south of Salem; one mile south of Shushan, and near Rock Hill schoolhouse (No. 8), Greenwich, Washington County, N. Y.

Hyolithellus micans var. rugosa, n. var.

Plate I, fig. 10.

This name is proposed for a variety of *Hyolithellus micans* that has well-marked concentric ridges with longitudinal striæ between them. The substance of the shell appears to be similar to that of *H. micans*. (See Bull. 30, U. S. Geol. Survey, p. 142.)

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates on the roadside just west of Low Hampton crossing of the Poultney river; lowest fossiliferous horizon on D. W. Reid's farm, and on hill back of Reid's farmhouse, one and one-half miles west of North Greenwich; two miles south of North Granville; and in the north part of Easton, about one mile south of the village of Greenwich, Washington County, N. Y.

Modiolopsis ?? prisca, n. sp.

Plate I, fig. 19.

The only specimen of the species known to me is the cast of a right (?) valve, 2^{mm} in length. It is transversely oval in out-

line and rather strongly convex; the beak is subcentral and curves toward the hinge line, but does not reach it; an oval muscular scar is situated just within the pallial line, at the supposed anterior end; pallial line simple, continuous as far as observed.

The minute size and the fact that we have only the cast of the interior of the valve, render it very difficult to determine the correct generic relations of this shell. The nearly central position of the beak distinguishes it from all known species of Modiolopsis; while the muscular scar and pallial line, with the oval form, relates it to *Modiolopsis curta* of the Hudson River formation. The discovery of the character of the hinge line may place it in a genus of the Arcadæ; but, at present, I do not wish to state more than that I think it is undoubtedly a lamellibranchiate shell. With the possible exception of *Fordilla Troyensis*, which, possibly, may be the shell of some Estheria-like crustacean, I know of no true lamellibranchiate shell in the Cambrian system of America, as defined in 1886. (This Journal, vol. xxxiii, p. 147, 1886.)

Formation and locality.—Cambrian. Limestone, interbedded in shaly Taconic slate, on the roadside north of School-house No. 4, in the northeast part of Whitehall, Washington County, N. Y.

Leperditia (I) dermatoides, n. sp.

Plate I, figs. 13, 13*a*.

Outline of the valves, elongate, suboval, with the extremities of the hinge line rounded, subangular; moderately convex, sloping more rapidly to the ventral than the dorsal margin; in many specimens, however, it is difficult to determine the ventral from the dorsal margin, owing to their almost equal curvature and similar rounding of the ends; the hinge line is arched and but slightly marked. It is difficult to determine the anterior and posterior ends of the valves in many of the specimens, but in others the narrower end is considered as the anterior, and a small, round depression on the inner side of the valve places the muscular scar well toward the posterior end. The scar is barely visible on the outer surface.

The test is finely punctate, and so thin that it wrinkled in some instances like a membrane or skin.

Length of undistorted specimen, 6^{mm}; greatest height, $3{\cdot}5^{mm}$.

The strongly punctate surface is so unlike that of all the species referred to Leperditia that it may be that this species should be referred to a distinct genus.

In its punctate surface and general form it is unlike any other species known to me.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slate; north part of Easton, about one mile south of the village of Greenwich; on the west side of D.W. Reid's farm and on the summit of the hill, northwest of his farmhouse, about one and one-half miles west of North Greenwich; about three miles northeast and one and one-half miles east of North Greenwich; near Rock Hill school-house (No. 8), east of North Greenwich; and one mile S.S.E. of Battenville, in the town of Jackson, Washington County, N. Y.

Aristozoe Troyensis Ford.

Plate I, fig. 8.

Leperditia Troyensis Ford, 1873. This Journal, III, vol. vi, p. 138; Walcott, 1886, Bull. 30, U. S. Geol. Survey, p. 146.

The discovery of another specimen of this species enables me to refer it to the genus Aristozoe of Barrande. The thin test, grooved and reflected ventral margin, anterior tubercle and general form, all serve to connect it with that genus. In Bull. 30, U. S. Geol. Survey, a figure is given of the right valve, and I am now able to figure the left valve. The tubercle on the anterior end is elevated and directed forward.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates, on the ridge east of the city of Troy, N. Y.; also at the lowest fossiliferous horizon, on the west side of D. W. Reid's farm, about one and one-half miles west of North Greenwich, Washington County, N. Y.

Aristozoe rotundata, n. sp.

Plate I, fig. 9.

General outline of the valves subrotund, with the exception of the nearly straight hinge line; anterior end slightly narrower than the posterior; general surface rather strongly convex, marked all around, except along the hinge line, by a strong marginal groove within a rounded marginal rim; a single elongate protuberance extends from the main body of the shell upward, just within the anterior marginal groove and the hinge line, where it is most prominent, and separated from the main body of the valve by a broad sulcus extending from the hinge line down on the valve over two-fifths the distance to the ventral margin.

The shell is thin and apparently very finely granulose.

A comparison with the types of the genus Aristozoe shows this species to be congeneric with them and specifically distinct from any described species of the genus. *Aristozoe*

*bisulcata** has a similar outline, but the tubercle is unlike that of *A. rotundata* and it is differently situated on the valves.

It is distinguished from *A. Troyensis* by its form and also the elongate tubercle or ridge.

The discovery of this species and the generic identification of *A. Troyensis* adds another Silurian genus to the Cambrian fauna and extends its range from the true Silurian down to the middle Cambrian. As yet I do not know of the presence of the genus in the Lower Silurian (Ordovician) rocks.

Formation and locality.—Cambrian. Limestones, interbedded in the shaly Taconic slates on M. C. Tefft's farm, about two miles southeast of North Granville, Washington County, N. Y.

Microdiscus connexus, n. sp.

Plate I, figs. 4, 4*b*.

Head semicircular, convex; bordered by a well-defined rim that is crenulated across the front and narrowed posteriorly toward the glabella where it terminates; cheeks most prominent at the postero-lateral portion, from whence they slope to the deep dorsal furrow about the glabella; the glabella and its backward spinose extension form, together, a fusiform median lobe, as there is no occipital furrow or ring, and the glabella and the spine are continuous. The glabella approaches the frontal margin more closely in some specimens than in others. The surface of both the head and pygidium appears smooth under a strong magnifying glass.

A glance at the head of this species recalls *Microdiscus punctatus*, *M. punctatus* var. *Pulchellus* and *M. Dawsoni* of the Lower Cambrian. It has the frontal rim and form of *M. Dawsoni*, but it is a smooth, not granulose species; and the associated pygidium is unlike that of *M. Dawsoni*. To *M. punctatus* it is related by its general form, but differs in the more coarsely crenulated margin, the form of the cheeks and its smooth surface, also in the characters of the associated pygidium. The presence of this type of the genus Microdiscus in association with well-known Middle Cambrian or Taconic fossils is another link between the Lower Cambrian fauna of New Brunswick and the Middle Cambrian fauna. It is the first instance known to me of the occurrence of a species with the long nuchal spine above the Paradoxides horizon in America.

Formation and localities.—Cambrian. Limestones, interbedded in the shaly Taconic slates, on the roadside just west of Low Hampton crossing of the Poultney river, one mile west of North Hebron, and two miles south of North Granville, Washington County, N. Y.

* Barrande; Syst. Sil. Boh., vol. i, Supplement, p. 477, 1872.

Olenoides Fordi, n. sp.

Plate I, figs. 5–5*b*.

Head rather strongly convex, frontal margin rounded, moderately elevated and separated from the glabella by a groove of medium width and depth. Glabella prominent, subquadrilateral, narrowing very slightly towards the broadly rounded front; three pairs of short, obscure furrows occur well down toward the dorsal furrow surrounding the glabella; occipital ring well defined and bearing a spine that projects upward and backward. Fixed cheeks about one-half the width of the glabella and curving slightly downward from the glabella to the palpebral lobe; ocular ridge strong and extending to and connecting with the rim of the palpebral lobe; eye situated midway of the facial suture and rather prominent in size and position; postero-lateral limbs short, broad and deeply grooved by the furrow within the posterior margin; at a point midway of the latter, a broad angle is formed and a rudimentary spine indicated.

The direction of the facial suture is well shown in the figure of the head on the plate. A free cheek, associated in the same hand specimen of rock, shows a low visual surface for the eye, a marginal rim similar to that between the facial sutures, and a short spine at the postero-lateral angle.

The associated pygidium is moderately convex, and bears a narrow, convex, median lobe, divided into five transverse segments and a short terminal segment; the lateral lobes are marked by four coalesced segments, indicating the continuation of the anterior segments of the median lobe; although broken by the smooth border, the segments may be traced into the four anterior of the six spines of the outer margin. Surface granulose under a strong magnifier.

A comparison with *Olenoides quadriceps* and *O. Wasatchensis* (Bull. 30, U. S. Geol. Survey) shows a marked resemblance in the pygidiæ, but, in the head certain differences occur, such as the narrower glabella and the wider furrow between the glabella and frontal rim of *O. Fordi*.

The species referred to this genus from the American Cambrian strata are: *O. Nevadensis* (the type), *O. Marcoui*, *O. quadriceps*, *O. Wasatchensis* and *O. Fordi*. In Bulletin 30, U. S. Geol. Survey, I referred *O. typicalis*, *O.? flagricaudus*, *O. levis* and *O. spinosus* to Olenoides, but since obtaining a nearly perfect specimen of Olenoides, closely related to the type species, I am convinced that the last mentioned four species belong to an as yet undescribed genus. This genus will be characterized in a future paper.

O. Fordi occurs in the lowest horizon of the Taconic slaty series now known to me, and is associated with *Olenellus asaphoides*, *Microdiscus connexus*, *Linnarssonia Granvillensis*, etc.

The specific name is given in honor of Mr. S. W. Ford, who has done such excellent work at this horizon about Troy, and Schodack Landing, N. Y.

Formation and localities—Cambrian. Limestones interbedded in shaly Taconic slates, on the roadside just west of the Low Hampton crossing of the Poultney River, two miles south of North Granville, and one mile north of Middle Granville, Washington County, N. Y.

Solenopleura ?? tumida, n. sp.

Plate I, figs. 2–2*a*.

This species differs from *Solenopleura ? Nana*, with which it is associated at several localities in having a more tumid glabella, narrower frontal lobe and in the absence of an ocular spine. Some specimens of *S.? Nana* have almost as tumid a glabella, but, usually, it is less elevated.

The generic reference is provisional, as both *S. ? tumida* and *S.? Nana* appear to belong to a genus distinct from the typical species of Solenopleura.

Formation and localities.—Cambrian. Limestones interbedded in the shaly Taconic slates near Rock Hill school house, (No. 8) east of North Greenwich; 1½ miles east and 3 miles northeast of North Greenwich; on the west side of D. W. Reid's farm about 1½ miles west of North Greenwich; ½ mile east of South Hartford post office; in the village of East Hebron; on the roadside just west of Low Hampton crossing of the Poultney River and one mile south of Shushan, Washington County, N. Y.

Solenopleura? Nana Ford.

Plate I, figs. 1–1*d*.

Solenopleura Nana Ford, 1878. Amer. Jour. Sci., III, vol. xv, p. 126; Walcott, 1886. Bull. 30, U. S. Geol. Survey, p. 214.

This species was not illustrated by Mr. Ford, and the specimens I had, when preparing Bulletin 30, U. S. Geol. Survey, were so poor that the illustrations then given were not satisfactory. Among the specimens in the collections from Washington County I find considerable variation in the convexity of the glabella and also in the granulose surface; and I suspect that with a large series of more perfect specimens there could be separated a variety if not a distinct species. The pygidium associated with *S. ? Nana* at Troy and also in Washington County, two miles south of North Hebron and one mile north of Middle Granville, has a spinose margin that recalls the pygidiæ of certain species of Peltura from the Swedish Cambrian.

Conocoryphe trilineata Emmons (sp.)

Plate I, figs. 7–7*b*.

For synonymy see Bull. 30, U. S. Geol. Survey, p. 203.

When examining the collections at Williams College, in 1886, I found the specimen from which the figure of *Atops trilineatus*, in Emmons's American Geology, pl. i, fig. 16, was drawn, and, through the courtesy of Professor S. W. Clarke, I have had a more accurate drawing made of it than the published figure. A study of the specimen, in connection with heads and pygidiæ collected from the original locality, shows that the species should be referred to the genus Conocoryphe,* as restricted by Corda, although *C. trilineatus* differs from the type of the genus *C. Sulzeri* in having a smaller pygidium and seventeen instead of fourteen thoracic segments; differences, however, of a specific rather than generic importance. The slender free cheeks have not yet been identified.

On plate xxvii, Bull. 30, U. S. Geol. Survey. figs. 1*a*, 1*b*, there are figures drawn by Mr. Ford of the species as identified by him at Troy, N. Y. The pygidium is similar to that associated with *Solenopleura? Nana* at other localities, and the head may be that of this species, but it is uncertain, owing to the imperfection of the specimens.

Formation and localities.—Cambrian. In black, argillaceous, shaly Taconic slate on the roadside near the old Reynolds Inn, now D. W. Reid's farm buildings about one mile west of North Greenwich; also in the northern part of Easton, about one mile S.S.W. of the village of Greenwich, Washington County, N. Y.

Ptychoparia Fitchi, n. sp.

Plate I, fig. 6.

This species is founded on a minute head that occurs in association with *Microdiscus connexus* and several other species of the lower horizon of the Taconic slate series. The elongate unfurrowed glabella, wide fixed cheeks and strongly granulose surface, all unite to give it a facies unknown in any other species with which I am acquainted.

Formation and locality.—Cambrian. In limestone, interbedded in the shaly Taconic slates, two miles south of North Granville, Washington County, N. Y.

* Mr. S. W. Ford states that this species has been shown to belong to the genus Conocoryphe (Amer. Jour. Sci., III. vol. xix. p. 152), but, up to the present time, I have not seen any proof of its true generic relations nor could it well be shown before more perfect specimens of the head were obtained than those illustrated by Emmons.

PTYCHOPARIA ? (*Subgenus?*) CLAVATA, n. sp.

Plate 1, fig. 3.

This is a minute trilobite, whose true relations are unknown. With the exception of its clavate glabella, it is related to *Solenopleura? Nana* and *S.? tumida* by the course of the facial sutures, wide fixed cheeks and small eye lobes.

Formation and localities.—Cambrian. Limestones interbedded in the shaly Taconic slates, 1¼ miles south of North Granville; on the roadside a little north of school house No. 4, in the northeast part of Whitehall; on the roadside just west of the Low Hampton crossing of the Poultney River; and near Rock Hill school house (No. 8), about a mile east of North Greenwich, Washington County, N. Y.

DESCRIPTION OF PLATE I.

[The natural size of the specimens is indicated by the lines beside the figures.]

Page.

FIGURE 1.—*Solenopleura? Nana* Ford 196
1, smooth variety of head; 1*a*, side outline of 1; 1*b*, side view of a granulose head that has faint glabella furrows; 1*c*, 1*d*, pygidium associated with the heads of this species.

FIGURE 2.—*Solenopleura? tumida*, n. sp. 196
2 and 2*a*, top and side views of head, except free cheeks.

FIGURE 3.—*Ptychoparia (?) clavata*, n. sp. 198

FIGURE 4.—*Microdiscus connexus*, n. sp. 194
4, 4*a*, summit and side views of head; 4*b*, associated pygidium.

FIGURE 5.—*Olenoides Fordi*, n. sp. 195
5, head, except free cheeks; 5*a*, associated pygidium; 5*b*, associated free cheek.

FIGURE 6.—*Ptychoparia (?) Fitchi*, n. sp. 197
6, head, except free cheeks.

FIGURE 7.—*Conocoryphe trilineata* Emmons (sp.) 197
7, finely preserved head with the exception of the narrow free cheeks; 7*a*, figure of specimen described by Dr. Emmons in his American Geology, pl. i, fig. 16; 7*b*, pygidium associated with heads and fragments of the thorax.

FIGURE 8.—*Aristozoe Troyensis* Ford 193
8, cast of left valve.

FIGURE 9.—*Aristozoe rotundata*, n. sp. 193
9, cast of the right valve. A row of vascular markings are quite distinctly shown on the lower portion of the valve.

FIGURE 10.—*Hyolithellus micans* var. *rugosa*, n. var. 191
10, enlargement of a fragment to show the rugose surface.

FIGURE 11.—*Stenotheca rugosa* Hall (sp.) .....
11, 11*a*, side views of two specimens to show the variation in the concentric undulations of growth; 11*b*, enlargement of the surface of 11. (For description of this species see Bull. 30, U. S. Geol. Survey, p. 128.)

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FIGURE 12.—*Protospongia*, sp. undet. .....
12, characteristic spicula.

FIGURE 13.—*Leperditia (I) dermatoides*, n. sp. 192
13. left (?) valve and outlines of its convexity; 13*a*, enlargement to show punctate surface and the wrinkled appearance of the test, as seen on some specimens.

FIGURE 14.—*Kutorgina pannula* White, (sp.) 190
14, dorsal valve; 14*a*, enlargement of surface of 14; 14*b*, enlargement of surface of a specimen from Pioche, Nevada, for comparison and also to correct the figure on pl. viii, Bull. 30, U. S. Geol. Survey.

FIGURE 15.—*Lingulella Granvillensis*, n. sp. 188
15, dorsal valve preserving portions of the outer shell; 15*a*, cast of the interior of a dorsal valve, showing muscular scars and vascular markings; 15*b*, 15*c*, ventral valves, showing elongate muscular scars and fragments of the outer shell.

FIGURE 16.—*Lingulella cælata* Hall, (sp.) .....
16, cast of the interior of a dorsal valve. (See Bull. 30, U. S. Geol. Survey.)

FIGURE 17.—*Orthis Salemensis*, n. sp. 190
17, ventral valve and outline of its convexity; 17*a*, dorsal valve.

FIGURE 18.—*Linnarssonia Taconica*, n. sp. 189
18, ventral valve; 18*a*, interior of ventral valve; 18*b*, cast of the interior of a ventral valve; 18*c*, dorsal valve; 18*d*, cast of the interior of a dorsal valve.

FIGURE 19.—*Modiolopsis? ? prisca*, n. sp. 191
19, cast of right (?) valve very much elongated. The outline of the convexity of the valve is shown by lines beside the figure.

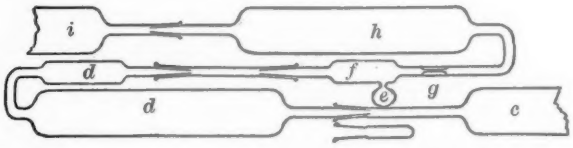
ART. XXIII.—*On the amount of Moisture remaining in a Gas after drying by Phosphorus Pentoxide;* by EDWARD W. MORLEY.

I HAVE now determined the amount of aqueous vapor left in a gas after drying it with phosphorus pentoxide, by the method applied in the case of sulphuric acid.* The process consists in drying the gas with phosphorus pentoxide, and then passing it through a weighed apparatus in which the gas is first slightly moistened, then much expanded, and lastly again dried by phosphorus pentoxide. If the weight of the apparatus decreases, the loss is due to the moisture left by phosphorus pentoxide in that volume by which the gas passing out of the apparatus exceeds the gas entering it.

If it were required in this matter to determine with some precision a physical constant, numerous experiments would be needed, and the results of the experiments now completed, show that each experiment would have to be continued for some years. But for settling a practical question concerning chemical manipulation, the two experiments now completed

* This Journal, vol. xxx, p. 141.

within three or four months may perhaps be thought sufficient. I therefore give some account of them, referring to the previous paper for further explanation of the principle of the method.



Part of the apparatus used is shown in the figure. *c* consists of three parts fused together: a Liebig's bulb tube filled with strong pure sulphuric acid, to effect the preliminary drying of the gas; a tube filled with powdered potassium hydroxide, to remove vapors of sulphuric acid; and a tube filled with phosphorus pentoxide mixed with glass wool, and having a plug of cotton wool at the exit of the gas. *dd* is a tube used as a counterpoise for the tube *efgh*, and having very nearly the same volume and the same surface as the latter. *efgh* consists of four parts. In *f*, air dried in *c* is made to take up a small quantity of moisture: it contains moistened calcium chloride. In *e*, at the beginning of an experiment, is contained about a gram of water: the size and length of the tube connecting *e* with *f* are used to adjust the absorption of water by the calcium chloride to the other circumstances of the experiment. At *g*, the tube connecting *f* and *h* consists in part of a very fine capillary tube. The diameter of this tube is reduced by fusion till the pressure of the atmosphere will force two or three cubic centimeters of air through it in a minute, provided that a vacuum be maintained at one end. In *h* is contained phosphorus pentoxide mixed with glass wool, and having a plug of cotton wool at the exit of the gas. *i* also contains phosphorus pentoxide: it is fused to a tube leading to a large reservoir connected with an air pump.

During the passage of a current of gas through the apparatus, *dd* and *efgh* have to be connected to each other and to the drying tubes *c* and *i*. Caoutchouc connectors would be a fruitful source of error in an experiment of such delicacy as the present. Whether the fact be that it is impossible to make caoutchouc tubes absolutely dry, that moist air diffuses through them, even against a greater internal pressure, or that gradual oxidation produces water as well as carbon dioxide, I have found it impossible to use such connectors when it was necessary to avoid introducing water into the apparatus at a rate of even a decimilligram in a day. All connections required

were therefore made by joints ground in a special way. Take for example the connection between *c* and *d*. *d* is to be weighed. The end of *d* is ground to a cone about fifteen millimeters long. The end of *c* is ground to a hollow cone about ten millimeters long, so as to leave about five millimeters of the end of *d* free from contact with *c* when thrust into it. If now a little fat of suitable consistency is put on the end of *c*, *d* thrust into it, and both gently warmed, a joint is made which is absolutely air-tight for small differences of pressure, provided that the layer of fat is not disturbed after solidification. It will be observed that at the joint between *h* and *i*, the difference of pressure is about an atmosphere; but any slight leakage here would only affect the measurement of the volume of air used in the experiment, and would not affect the weight of the weighed apparatus, because a slow current of moist air entering here would be swept along into *i* by the current of three liters an hour passing out of *h* during the experiment. Further, direct experiment with such a joint showed a leakage of much less than a cubic millimeter of air in three months. It may be fairly assumed that the *diffusion* of moisture through the layer of fat in each joint is negligible for the present purpose. In any experiments where this assumption ought not to be made, the joint would be surrounded by air kept dry with phosphorus pentoxide, or by a vacuum. It may be added that if such a layer of fat has to be disturbed after solidification, as by turning a plug or stopper, the problem of making an absolutely air-tight joint is very different from that in the present case.

The weighing of drying tubes with an error of less than a decimilligram is difficult. Two hollow cones were ground to fit each end of the tubes to be weighed; one was used to connect this tube with other parts of the apparatus, and the second was fused together, making a cap, as shown between *c* and *d*. Caps 1 and 2 fitted *dd*, caps 3 and 4 fitted *efgh*. All these caps having a suitable quantity of fat applied, 1 and 2 were counterpoised against 3 and 4, and the difference of weight determined by careful weighings for a few days. The end of *h* was withdrawn from *i*, carefully wiped free from the fat which had made this joint tight, and 1 was put in place; 2, 3 and 4, were successively put in place, and the barometer and thermometer were noted. Each tube was carefully washed, and then polished with a dry cloth, but nothing was brought near the fat on the caps. The difference in weight between *efgh*, caps and fat, and *dd*, caps and fat, was determined by weighings for several days. The hygroscopic surface of the tube *efgh* was so nearly equal to that of *dd*, and the volumes of air displaced by *efgh*, on the one side, and by *dd* and the

required brass weights on the other side were also so nearly equal, that no variations of a decimilligram were noted in the eight, ten or fifteen days used in the weighings. Subtracting the difference of weight of caps and fat from the difference of total weight, we have the difference of weight of tubes *efgh*, and *dd* with their contents, solid or gaseous. Now, since care was taken to close the tubes at the end of the experiments at an hour when the barometer and thermometer showed the weight of a given volume of air to be the same as when the tubes were closed at the beginning of the experiment, a comparison of the two differences thus determined at the beginning and end of an experiment would show the loss of weight of the contents of *efgh*. It was assumed that the difference of volume between $H_2O+P_2O_5$ before; and $2HPO_3$ after, an experiment was negligible for the quantity of water used.

Using many precautions too minute to be detailed, there was no difficulty in determining the difference of weight of the two apparatus as accurately as the difference of two brass weights. The whole weight on each pan was 35 grams; a Becker balance intended to carry 100 grams in each pan was used. Weighings could therefore be made to the fortieth of a milligram. The tubes were left untouched for many days, in a room without artificial heat, surrounded by rooms kept at a pretty constant temperature, and their weights compared from twenty to fifty times. The results obtained were as constant as were obtained on the same balance in ascertaining the relations of the set of weights used with it.

The details just stated show that it is not impossible to secure equality of hygroscopic state in two equal surfaces freshly made of the same glass. The outer surfaces of *dd* and of *efgh* therefore do not interpose any serious difficulty in the way of accurate weighing. But the inside of *dd* has to be in the same hygroscopic state at the beginning and the end of an experiment lasting many weeks.

To secure this, dry air from *c* was passed through *d* for a long time while it was heated to 200° or 250° C. When *d* had thus been made as dry as possible at this temperature, the end of *d* remote from *c* was closed with its weighed cap and charge of fat. *efgh* was connected with *i* at one end, and closed by its cap at the other. *dd* and *efgh* were left side by side for a day to attain equality of temperature and pressure, disconnected from *c* and *i*, and closed with their second caps at the same time. After weighing, *dd* and *efgh* were connected as shown in the figure. Now, since during the experiment, only air dried in *c* passes through *d*, and since the experiment proves that this air contains no appreciable amount of moisture, the interior of *d* absorbed no moisture; and it lost none, for its

temperature was far below that at which it had been dried. Therefore the hygroscopic state of the interior was constant.

When *dd* and *efgh* had been prepared and weighed, they were connected, as described to the tube *i*. This tube, intended to prevent the passage of moisture from the air pump to the tube *efgh*, was fused to a tube carrying a syphon barometer gauge, and a mercurial stop-cock leading to the air-pump, and connected to a copper vessel holding 54·1 liters. The connection of the glass tube to the copper reservoir was immersed in water: this water jacket and the mercurial stop-cock secured the certainty that all air entering the receiver must come through the tubes *c* to *i*. The pressure in the receiver was reduced till the flow through *h* was about three liters an hour, and was measured on the gauge. When the pressure had risen by a suitable amount, it was again measured, and again reduced. When the water in *e* and *f* was exhausted, air was slowly admitted to the receiver by breaking off a sealed capillary tube; when the pressure in the receiver was equal to that of the atmosphere, a free communication was made between the air and the tubes *i* and *c*, and when the air had a suitable density, the caps were applied and weighings made as already described.

In an experiment lasting through December, 1886 and January, 1887, 726 liters of air passed through *c* and *d*. They were expanded to 2428 liters in *g*, and passed through *h* at the rate of 70 liters in a day. The excess of the volume passing out was 1702 liters, and the loss of weight in the tube *efgh* was rather less than the twentieth of a milligram. In an experiment lasting from February to April, 1887, the volume of air entering was 211 liters, the expanded volume, which passed at the rate of 75 liters in a day, was 2841 liters, and the excess was 2630 liters. The loss of weight of the apparatus was rather more than one twentieth of a milligram. The measured volumes may well be in error by one or two per cent.

The weight of aqueous vapor left in a gas passing at a rate of three liters in an hour through a tube two centimeters in diameter and eight centimeters long compactly filled with phosphorus pentoxide and glass wool, is therefore so little, that in 4300 liters it cannot be detected with much probability by even the most delicate weighing.

It is obvious that if at some future time physicists should need to know the tension of the vapor of water in presence of phosphorus pentoxide, an experiment by this method must be greatly prolonged. With a current of three liters an hour, the effect measured was not over a decimilligram in two months. To obtain some such quantity as ten milligrams might therefore require ten years. But for the purposes of the chemist the present two concordant results may for a time be sufficient.

Van der Plaats, giving more than sufficient credit to the previous experiments on sulphuric acid, has suggested in a note that the experiments were but few in number, were in fact, but preliminary (provisoire) and that it would have been better to produce the current of air by pressure. With the connections used, whether a current be produced by excess or defect of pressure is perfectly indifferent. The leakage at any joint was proved to be less than a tenth of a cubic millimeter in the time of an experiment. The experiments were also of such number and character as to be final (at least for the present), as to the question whether the use of sulphuric acid for drying gases in the ordinary course of analysis or research introduces any measurable error.

Our knowledge of the behavior of the three principal drying agents is now as complete as is needed at present. Dibbits showed how much moisture is left unabsorbed by calcium chloride at different temperatures. He also established the difference between the amounts left unabsorbed by sulphuric acid and by phosphorus pentoxide. I have shown previously that sulphuric acid leaves unabsorbed not far from a fourth of a milligram of moisture in 100 liters of a gas. Now it appears that the moisture left unabsorbed by phosphorus pentoxide, if capable of determination, may be very roughly stated as possibly a fourth of a milligram in 10,000 liters.

749 Republic St., Cleveland, Ohio, May, 1887.

Art. XXIV.—*Is there a Huronian Group?** by R. D. Irving.

Synopsis of Contents.

I. Starting with a statement of the values of the terms *System*, *Group* and *Formation*, as used in the nomenclature recently proposed by the Director of the United States Geological Survey, this paper enquires whether there can be carved off from the upper part of the great complex of rocks ordinarily known as Archæan, a *Huronian* series, entitled to rank with such groups as the Cambrian, Silurian, etc.

II. The rock series of the north shore of Lake Huron, between the Mississagui and St. Mary's rivers, mapped by Logan on Plate III of the atlas to the Geology of Canada, 1863, is the original or typical Huronian, and no other. The enquiry must then begin with this region.

III. This typical series of rocks is next shown to be entitled to the group rank by (1) its intrinsic characters, and (2) its structural, and consequently its chronological separateness from the older Archæan, and younger Cambrian and pre-Cambrian rocks of the region.

IV. The so-called Archæan rocks of the Marquette, Menominee, and Penokee districts of the south shore of Lake Superior are next considered, in the order of the districts named, and are shown to present the same divisibility into an upper detrital, and a lower crystalline schist member, which members are to be correlated respectively with the type Huronian, and with the crystalline rocks beneath

* Read by invitation before the National Academy of Sciences, at Washington, D. C., April 22, 1887.

t. This correlation is supported by: (1) a similarity of structural relations between the series correlated, in the different districts; (2) a similarity of lithological characters, group for group, and (3) a similarity in general stratigraphical position.

V. Attention is next invited to the region north of the western half of Lake Superior, the so-called Animiké series of which is the equivalent of the Penokee iron-bearing series, and hence of the original or type Huronian.

VI. The iron-bearing belt of the Vermilion Lake region of northern Minnesota is next considered, and found to furnish a case where newer detrital rocks have been folded in with the basement rocks, so as largely to obliterate the appearance of unconformity, a true schistose structure having at the same time been developed in the detrital series.

VII. The several discordances thus passed over in review—i. e., those respectively beneath the Animiké series, the Penokee iron-bearing series, the type Huronian of Lake Huron, the Marquette iron-bearing series, the Menominee iron-bearing series, and the Vermilion Lake iron-bearing rocks—form, in the order named, a graded series as to the degree of modification of the original discordances. When the subsequent disturbance has been great, cases must arise where the distinction between the two sets of rocks becomes very difficult, or even impossible.

But in all the several districts named there is plainly recognizable the same discordance, due to the same orographic disturbance, between the same sets of rocks.

Throughout the region stretching from the north shore of Lake Huron westward to the Mississippi River, in central Minnesota, there is recognizable the following order of succession, beginning below:

(1) The great basement or *Laurentian* complex of gneiss, granite and crystalline schists; as to whose further divisibility no opinion is now offered. This is separated by a great discordance from

(2) The *Huronian*, a detrital iron-bearing series. A further discordance severs this from

(3) The *Keweenawan* series of interleaved detrital and eruptive beds. This series again is entitled to the group rank. Above the Keweenaw series and separated from it by yet a third great discordance, follows:

(4) The *Potsdam* or Upper Cambrian sandstone.

VIII. Correlations of rocks of regions other than that now especially referred to, with the type Huronian, have generally been made without much foundation, having been based only on similarities to a fictitious lithological standard. Cautiously made correlations, however, for regions not too distant from each other, may have some value when based on a comparison of great discordances; since these discordances indicate the intervention of mountain-making movements of a necessarily wide-spread influence; but the more general correlation—collectively—of all the clastic groups, which in any one region intervene between the Cambrian and the basement crystallines, with any group or groups falling within the same interval in other regions, is the only one which is at present of any general application.

IX. The Huronian and the Keweenawan—and also such other groups of rocks as are found in other portions of the world beneath the Cambrian base, and above the Archæan schists—should be admitted to the geological column with the group rank. This admission, however, renders desirable a modification of the lower part of the column. It is suggested therefore that the term Archæan be used to cover only the pre-Huronian basement crystallines; that the Cambrian group remain as the basal member of the Palæozoic System, and that the new system name *Agnotozoic*, first proposed by Professor T. C. Chamberlin, be used to cover, at least provisionally, such clastic groups as intervene between the Cambrian base and the Archæan schists.

I. According to the system of nomenclature recently proposed by the Director of the United States Geological Survey,*

* As set forth in a paper presented at the International Geological Congress, (held in Berlin in 1885), and published in French at Paris in 1886, under the title of "Methodes de Cartographie Geologique Employés par L' United States Geological Survey."

the great fossiliferous rock complexes are classed in three orders of magnitude, namely: the *System*, the *Group*, and the *Formation*. Of these classes the most comprehensive is the *System*, which term is applied to those great divisions of the geological column which are defined by palæontology, and are recognizable the world over. Such are the Cenozoic and the Mesozoic Systems. Next in order comes the *Group*, which term is designed to cover those great sub-divisions of the Systems which are "defined above all by palæontology, and subordinately by petrography, or are admitted by all geologists, for motives in part arbitrary. These are the groups. Those admitted by the Survey have been discovered in various countries; they have probably a universal distribution,* comprising all the formations of known clastic origin, and appear to be approximately comparable among themselves as to volume. It is not maintained that their limits are clearly marked, nor that they can be strictly traced along equivalent stratigraphical levels. Nor yet is it held that the testimonies of the different classes of fossils—vertebrates, invertebrates and plants—are always consistent with each other, or with that of petrography, as to their limits. These divisions are, then, to a certain extent arbitrary. We may increase or diminish their extent from time to time by adding or withdrawing formations in the neighborhood of their respective boundaries, just as the orders of biology are perpetually modified. . . . "† Such are the Cambrian, Silurian, Devonian and Carboniferous Groups. These generally recognized subdivisions of the geological column are *groups*, especially in the sense that they include each a number of subordinate divisions distinguishable from one another petrographically, genetically, and often even palæontologically. These subordinate members finally are the *Formations* of this system of nomenclature, though the use of the term formation is allowed also in a vaguer sense to cover any rock mass whose distinction from the surrounding masses is desirable on one ground or another.

In the paper referred to, this classification is proposed only for what are in it termed the clastic groups—*clastic*, in the sense that they are formed mainly of débris, whether it be of preëxistent rocks or of the hard parts of organisms. The rocks composing the groups have been deposited by the ordinary processes of sedimentation. Outside of these so-called clastic groups are left to be separately provided for the various rocks which have been termed collectively the crystalline schists, and which, in the paper referred to, are embraced under

* This is the signification of the French; but in the original English MS., from which the French translation was made for publication, this clause reads, "are presumptively world-wide in distribution."

† Translated from the French of the original article, op. cit., p. 15.

the general term of "non-eruptive crystallines." These are set off by themselves collectively because, while it is admitted that the larger part of them are of an age greater than those of the recognized clastic groups, it is desired to avoid for the present the still disputed points: (1) as to whether some of them are not altered clastic rocks of later geological age; and (2) as to whether those which unquestionably belong below the base of the ordinarily recognized Palæozoic groups are, or are not, divisible into members of a taxonomic rank equal with that of those groups.

It is with this latter question, or rather with a portion of it, that the present essay concerns itself. I say a portion of it because the general question as to what groups, if any, we should recognize among the pre-Cambrian rocks would be quite too broad a one for the space that can now be occupied. Not to speak of other points that would have to be considered, the answer to this general question would involve, in the first place, a discussion as to the separate existence, and taxonomic relations of the so-called Keweenaw Series of Lake Superior. My design is then merely to inquire if there can be carved off of the upper portion of the great complex which has been called Archæan, a series of *Huronian* rocks; a series entitled—by structural and genetic separateness, by clastic origin, by largeness of volume, and by the being made up of subordinate divisions of the formation rank—to the rank of a group, i. e., to a rank equal in classificatory value to the Cambrian, Silurian, etc.

II. The term *Huronian* seems first to have been used in a publication prepared for the Paris Exposition of 1855, by Sir Wm. Logan and Dr. T. S. Hunt, on part of the Geological Survey of Canada, and entitled "Esquisse Géologique du Canada." As used in this volume, however, the term has but a very vague and unsatisfactory signification. To begin with, it is used only as a synonym of *Cambrian*, and is not made to apply especially to any one individual or typical area, but to embrace vaguely defined series of rocks occurring in various wholly separated areas on Lakes Superior and Huron, which series may or may not be geologically equivalents of one another so far as any evidence presented goes to show. Moreover, the term is made to cover also the great and wholly distinct succession afterwards separated out as the Copper-Bearing or Keweenaw Series.

The term Huronian was afterwards used in various reports of the Canada Survey, with a somewhat changing signification, until, in 1863, Sir William Logan gave, in the Geology of Canada, a thoroughly definite account of the series, including

all information to date. With this description he gives also a detailed map and sections of "The Huronian Rocks" on the north shore of Lake Huron, between the St. Mary's and Mississagui rivers. This particular series Murray had described as early as 1848, as "a set of regularly stratified masses, consisting of quartz rocks or altered sandstones, conglomerates, slates and limestones, interstratified with beds of greenstone." Although both Logan and Murray extended the name Huronian to other rocks in the Lake Superior region this series was the only one so covered that was ever studied and mapped in any thorough manner, while the correlation of the other so-called Huronian areas with this one rested always on a pretty slender foundation. If then we seek—as we must do—for a type series with which to start a study of the so-called Huronian, we can find it only in this Lake Huron Series. This seems indeed to have done duty more or less definitely as such a type in the writings of European and American geologists for five and twenty years; although, most unfortunately, of the many who have made use of the name Huronian, only a very few have studied these rocks on the ground, in any such manner as to warrant the opinions they have so freely expressed.

Evidently our inquiry should begin with a study of this type series of rocks. Is this series, in its nature, volume and subordinate divisions, entitled to the rank of a clastic group? Do its structural relations and lithological contrasts with the great mass of the Archæan, with which it is in direct contact, indicate a chronological separateness? In attempting an answer to these questions, I make use not only of the facts summarized in Logan's descriptions and upon his map, but also of the results of my own observations extended during two seasons, not only in the area especially mapped as Huronian on the plate to which I have already referred, but also over a large contiguous area further to the eastward, which has been mapped as Huronian on the recent general maps of the Canadian Survey.

III. Briefly, then, that series of rocks, which is especially mapped by Logan on the plate above referred to, and which we may properly designate as the type or original Huronian, may be described as a great succession of quartzite layers, including a subordinate quantity of greywackes, a much smaller proportion of "limestone and chert" and numerous eruptive diabasic greenstones; the latter occurring both in dyke and sheet form. In the main the series is but very gently bowed. Only rarely the inclinations of the strata reach twenty degrees, while large areas occur, particularly in the interior and away from the lake shore, where the strata are not visibly removed from horizontality, the whole appearance of the topography in

such cases recalling strongly many regions of later horizontal strata, for instance that of the upper Mississippi valley.

According to Murray and Logan*—for whose painstaking accuracy and general geological insight I acquired the greatest respect while passing over the region, with their map and descriptions in hand—the series is made up of the following succession of strata, in ascending order, viz:†

Fig. 1. Section of the original or type Huronian, showing its relation to the pre-Huronian crystallines, Lake Huron. Scale, 10 miles to the inch. Reduced from Logan's section. *a–b*, Laurentian; *b–c*, Huronian; *d*, Cambrian and Lower Silurian.

	Thickness in feet.
1. Gray quartzite	500
2. "Chloritic and epidotic slates interstratified with trap-like beds"	2000
3. White quartzite, often conglomeratic	1000
4. "Slate-conglomerate, composed of pebbles of gneiss and syenite, held in an argillaceous cement of a gray to greenish color"	1280
5. Limestone, thin-banded, often argillaceous	300
6. "Slate-conglomerate," like No. 4	3000
7. Red quartzite	2300
8. "Red jasper-conglomerate;" a quartzite with frequent red jasper pebbles	2150
9. White quartzite	2970
10. Yellow chert and limestone	400
11. White quartzite	1500
12. Yellow chert and impure limestone	200
13. White quartzite	400
Total	18,000

* In the discussion which followed the reading of this paper, the point was made that I gave too much credit to Logan and too little to Murray, in the matter of the working out of the original or type Huronian series. My wish, of course, is to do exactly right in such a matter; but it is very difficult for one not familiar with the inside history of the Canadian Survey, particularly after the lapse of so many years, to adjust the credits correctly. In the Geology of Canada of 1863, which must serve as the source of information, the description of the series is all in Logan's own words, plainly. He also speaks distinctly of having examined this region in person (Preface, p. v); while Mr. Murray's examinations are said, in a general way only, to have extended over "Western Canada." In the atlas accompanying the Geology of Canada, however, it is said that the detailed map of the Huronian (Plate III, of the Atlas), to which reference is made above, is "chiefly from the surveys of Mr. Alex. Murray." The sections accompanying this map were drawn by Logan himself. (See Preface to Atlas, p. iv.) It would seem that Logan, after examining the ground himself to some extent, made use of Murray's more detailed studies also, from which to construct the map and sections himself, and to prepare the general description.

† Abbreviated from Logan's detailed section given in the Geology of Canada, 1863, pp. 56–58.

The thicknesses of the interbedded eruptives are not separately given, but their subtraction would not seriously affect these figures, except in the case of division No. 2, which, as subsequently shown, is very largely composed of diabase sheets. Placing together the several kinds of material composing Logan's section, without reference to stratigraphical order and without making any correction for included eruptives, the series is seen to be composed as follows: quartzite, 10,820 feet; "slate conglomerate," 4280 feet; "chloritic and epidotic slates and trap" 2000 feet: limestone and chert, 900 feet=18,000 feet. But a much more accurate conception of the relative proportions of the different kinds of rocks which constitute this series may be reached by making several important modifications of this statement. In the first place my own examinations of the ground, while they have served to convince me of the general correctness of Logan's section, have shown me that considerable portions of his "slate conglomerate" members are made up of quartzites, the remainder of these members being composed of dark-colored fragmental rocks, to which the name of greywacke more nearly applies than any other given in the books. Moreover, that portion of the series designated by Logan as "chloritic slates and traps" (No. 2), I have found by a study on the ground, and of a number of thin sections, to be mainly composed of a succession of diabase-sheets, along with which is a little interleaved fragmental material, perhaps partly of the nature of volcanic ash, but with which there is also some true sedimentary material. Taking these facts into account, and remembering also the interleaving of greenstone sheets at different horizons in the series, I estimate the whole succession to be about two-thirds quartzite, one-sixth greywacke, and one-twentieth "lime-stone and chert," the remainder being chiefly composed of eruptive material.

Of these rocks the *quartzites* are all no more nor less than indurated sandstones, without prominent schistose structure. The induration—which varies so greatly in degree that some of these rocks are almost loose sandstones, while others are completely vitrified quartzites, the two extremes occurring at times in close association with one another—is always due to the presence of an infiltrated silica. This infiltrated material occurs partly in the shape of a minute mosaic between the plainly recognizable rolled fragments of quartz, of which the rock is mainly composed; but is for the most part in the shape of enlargements or secondary growths to these fragments. This process of enlargement, which I have described and illustrated freely elsewhere, is one which, as I have been able to show, has affected fragmental quartzose rocks of all ages, from the most recent to the most ancient. Every stage in the development

of the process is recognizable among these ancient quartzites, as well as in the similar rocks of more recent formations. Even in the extent to which this indurating process has been carried on, the Huronian quartzites do not differ so remarkably from many sandstones of much later periods, like which they show also the ripple and other markings so characteristic of water-deposited sand.

The dark-colored fragmental rocks of this series, which I have embraced under the general head of *greywacke*, and which vary in coarseness of grain from aphanitic, slaty kinds to rather coarse grits, and are often dotted with pebbles and bowlders of granite and gneiss, are, equally with the quartzites, genuine clastic rocks, often differing in no respect from similar rocks found in various portions of the world, and at various horizons in the Palæozoic series, where they are found to be frequently highly fossiliferous. Indeed, these Lake Huron greywackes have on the whole undergone much less alteration than many fossiliferous rocks of a similar nature. Those of the north shore of Lake Huron are very regularly stratified, gray to black, often ripple-marked, compact aggregates of rounded to subangular mineral fragments, which include, besides pieces of quartz, particles of various other minerals, particularly of feldspars. Often the fragments are recognizable as particles of rocks, the disintegration having left the different mineral ingredients attached to one another. The thin sections of all of these greywackes show that their indurated condition is due partly, perhaps mainly, to a secondary deposition of interstitial quartz, entirely analogous to that just described as characteristic of the quartzites of the series; but that it is also due in part to a very general development of chloritic material from the feldspar fragments, to the presence of which chloritic ingredient the dark color of the rock is mainly due.

Limestone is made by Logan to constitute more or less of three numbers of his succession (Nos. 5, 10 and 12; respectively, 300, 400 and 200 feet in thickness). The lowest one of these three bands, which occurs in the lower half of the series, and is finely exposed along the shore of Lake Huron about two miles west of Bruce Mine Bay, is a thin-bedded, dark gray, often brown-weathering, compact and earthy-looking limestone. The very striking and regular thin lamination, which is brought out with the greatest prominence on weathered surfaces, the more impure laminæ being left projecting in little ridges above the more purely calcareous ones, seems to place the sedimentary origin of this rock beyond a question. This conclusion is borne out very emphatically by the appearance of the thin sections, which show distinctly a fragmental material mingled with the felted mass of minutely crystalline car-

bonate, the whole appearance of the section differing in no respect from sections I have examined of Palæozoic limestones. Not that it seems to me necessary to believe in a direct organic origin for the carbonate of lime contained. The whole process may have been a combination of the mechanical and chemical kinds of sedimentation such as we find exemplified in the clayey beds of the Coal Measures carrying carbonate of iron, and at various other geological horizons. The two other lime-bearing members of the series as marked by Logan are spoken of by him as very largely cherty, and as including here and there sandstone layers. In our own examination of these beds, made chiefly in the back country between Echo Lake and Garden River, it appeared to us that the cherty material predominated very largely over the calcareous. In this region the cherty layers are almost entirely horizontal, the whole appearance of the bluff sides of the exposures being that ordinarily presented by the horizontal formations, as, for instance, in the upper Mississippi valley. This horizontality, taken along with the very thin lamination of these rocks, and the presence of more or less distinctly detrital material, as is observable on the larger scale as well as microscopically, serves to place beyond question the sedimentary origin of these layers. Often these cherty beds are quite ferruginous, and at the same time brecciated, in which case they parallel very closely occurrences in the Marquette and Penokee iron regions on the south side of Lake Superior, and are not unlike occurrences among some of the later fossiliferous formations. Whatever may be true, then, of the origin of those great masses of coarsely crystalline limestone which are associated with the ancient gneisses, no doubt can be entertained of the sedimentary origin of these limestones of the original Huronian. Moreover, they have undergone since their first deposition changes no greater than are attributable to the action of infiltrating waters, or than those often found among the Palæozoic limestones.

Of the four principal kinds of rocks which constitute the series according to the estimate I have given above, there remain to be mentioned only those crystalline rocks which I have spoken of collectively under the convenient term of *greenstone*. Of these I need now say only that they are mainly diabases in no important respect different from eruptive diabases at various other horizons, that they are mainly non-schistose, and that they present no sign whatever of gradation into the adjoining sedimentary strata.

Thus the first part of our inquiry, with regard to the original or type Huronian is answered in the affirmative. Intrinsically, it is fully entitled to the group rank. Its detrital or clastic origin; its largeness of volume; its inclusion of a number of

subordinate strata—each entitled by its thickness and petrographical distinctness to be classed with any of the "formational" subdivisions of any of the Palæozoic groups—combine to give it this position. But it remains to be considered whether there is equally strong warrant for believing this series to be structurally, and consequently chronologically, separable from the adjoining portions of the so-called Archæan. Is it not possible that we are merely setting off arbitrarily a set of rocks which is really only part and parcel of the whole great Archæan complex, and is not separable by any genuine line of demarkation?

Before attempting to reply to this part of the problem it will be well to understand what sort of evidence that must be whose production will establish a degree of chronological separateness sufficient to warrant the ranking of this original Huronian as a Group. Such a degree of separateness, then, can only be established when we have in hand good reason for a belief in the subjection of the underlying rocks, as a land surface, to a long-continued atmospheric erosion, before the deposition upon them of the detrital series whose group rank it is desired to establish. In the cases of discordances between groups higher in the geological scale than that we are now considering, the rocks *below* as well as those *above* the discordance are of unquestioned sedimentary origin; so that in such cases we have indicated two periods of submergence, separated from one another by one of disturbance, emergence and erosion. But this accepted aqueous origin for the lower rocks is not essential. We may have equally good reason for a belief in a lengthy intervening period when the lower rocks are crystalline schists, as to whose origin there may be question, or sometimes even when they are eruptives. In the former case the foliation, schistose structure, and general crystalline character of the lower rocks, when contrasted with the absence of such characteristics in the higher, indicate the subjection of the former to long-continued and deep-seated processes of alteration, whatever the first origin, and consequently to profound erosion, before the deposition upon them of the overlying detritals. Fragments of the lower crystalline rocks occurring in the higher detritals, particularly at the contacts of the two, serve greatly to strengthen such a conclusion; since these must be taken as a final demonstration of the production of the schistosity and foliation prior to the long-continued period of denudation which in turn must have been accomplished before the detrital deposition began. Somewhat similar reasoning will serve even if the lower rocks are of non-schistose, plutonic kinds ("tiefen Gesteine" of Rosenbusch), since these must have cooled at great depths, and must have been deeply denuded before the

masses of the different kinds of eruptives could be truncated or yield fragments to detrital deposits. In case the basement rocks are a combination of plutonic eruptives with crystalline schists, additional proof may be found in the fact that the eruptives intersect the schists, while they are truncated by the overlying fragmental rocks, to which also they have yielded fragments.

Now all of this evidence is forthcoming in the original Huronian region, and in the clearest and most unequivocal manner. The Huronian series is detrital and non-schistose; the underlying rocks are crystalline schists (mainly mica-schist), gneiss and granite; the mica-schists being without remaining fragmental texture, though at times banded in such a manner as to render an original fragmental condition very probable. The upper rocks are not intersected by the granite where the two come in contact; the lower schists and gneiss are deeply invaded by it in great bosses, in irregular masses of smaller size, and in an intricate net-work of veins; as may be seen most beautifully eastward from Algoma Mills, on the Lake Huron coast, and along the line of that branch of the Canadian Pacific Railway which extends from Algoma Mills to Sudbury on the main line.

Fragments of the older rocks occur in the detrital series at various horizons, but in most especial beauty at the contacts of the two series. These latter conglomerates are true *basal* conglomerates, whose asserted absence certain geologists* have urged with much emphasis as an argument against the existence of any separate Huronian series; i. e., separate from the remainder of the great Archæan complex. I may therefore not improperly enlarge somewhat on their actual occurrence. Probably the handsomest instance is that at the contact of Logan's basal member of the series, on the Lake Huron coast, about three miles east of the mouth of Thessalon River. From this point

FIG. 2. Section about three miles east of the mouth of Thessalon River, Lake Huron, showing conglomerate at the base of the Huronian. Scale, 400 feet to the inch.

eastward the older gneiss, granite, etc., spread along the coast to Algoma Mills, and beyond. The contact is best seen in a group of small islands lying close to the mainland. These islands are moutonnéed to a very high degree, and are largely bare, so that the rocks are finely displayed. The figure is a section through three of these islands, the middle one of which shows the granite and gneiss at one end, and, resting

* J. D. Whitney and M. E. Wadsworth, in the "Azoic System," pp. 556, 557.

upon these and filling the irregularities of the original surface, the conglomerate rock, which dips some thirty degrees toward the northwest. The stratiform arrangement of the conglomerate is finely brought out by the interleaving of sandy layers, in which the pebbles are wanting, or nearly so. The sub-angular to angular fragments of the conglomerate, ranging in size from a fine detritus to bowlders two feet in length, are confusedly heaped together in the vicinity of the immediate contact; but further away show a tendency to arrangement in bands. They are mainly composed, in order of relative abundance, of a gray biotite gneiss or gneissoid granite, of red granite (including several varieties) and of dark-colored schists. The matrix, which is at times almost or wholly excluded by the bowlders, is mainly a fine detritus of the same nature as the fragments, the constituent minerals of the original rocks becoming more thoroughly separated from one another as the particles are finer. This finer detritus becomes more quartzose and arenaceous in the interleaved, non-conglomeratic layers, particularly as one passes away from the immediate contact. In these portions also there is present more or less of a kaolinic or sericitic ingredient resulting from the decay of the feldspathic constituents. Finally, invading the matrix very irregularly, at times giving it the appearance of a completely vitreous quartzite, and again leaving it very arenaceous in texture, is a siliceous cement, which has partly separated out as a finely interlocking quartz but often has divided itself off more or less thoroughly as enlargements of the quartz fragments. Upwards the conglomerate graduates into an arenaceous quartzite.

Closely analogous phenomena are to be seen at the contacts of these two sets of rocks displayed at three points on the line of that branch of the Canadian Pacific which runs from Algoma Mills to Sudbury on the main line, and particularly in the vicinity of the mouth of Serpent River. The pebbles and bowlders at these contacts are of all sizes up to two or three feet in diameter, and include granite, gneiss and mica-schist. It should be added that fragments of gneiss and granite are met with at various horizons through the Huronian series, often in considerable abundance in one place, while large parts of the series are composed of a little assorted granitic and gneissic detritus. These pebbles, and the finer gneissic detritus, though not at the base of the series, furnish strong evidence of the relatively great antiquity of the rocks which yielded them.

Thus the structural relations of the original or typical Huronian series to the older schists are such as to render abundantly evident its entire chronological separateness from them; and the second part also of our inquiry is answered in the affirmative.

Returning now to the classification of rocks and the characterization of the Group, quoted at the beginning of this paper, it will be seen that under this classification the Huronian can only be a group, since—(1) *it is essentially non-crystalline*, and therefore not to be placed with the non-eruptive crystallines, from which, moreover, it is structurally wholly separate; (2) *it is truly clastic and sedimentary*, and therefore must be included with the clastic groups, because these "comprise all the formations of known clastic origin;" and (3) *it has an immense volume*—a volume not only comparable with those of the ordinarily recognized fossiliferous groups, but in excess of the volumes of many of them. It cannot be a formation, being made up of formations. The classification then leaves us no choice but to call it a group.

The definition quoted demands, it is true, some other characters for the group in addition to those just mentioned, but since the latter are restricted by it to the true group, it is evident that in the original Huronian we are dealing with one of these groups, or that the definition is defective. This point I return to in the closing section of my paper, and may therefore pass it over for the present, merely remarking by the way that the question which has been raised by some, as to whether the Lake Huron Huronian may not be the equivalent of some group elsewhere recognized as fossiliferous, say the Cambrian or the Silurian, is hardly worthy of discussion. Here, in the typical region itself, the Upper Cambrian sandstone (Potsdam) may be seen crossing the immensely denuded surface and decapitated folds of the Huronian; so that to include the Huronian even in the Cambrian would require us to stretch that term over one of the greatest, if not *the* greatest, of the structural gaps in the whole geological column. Moreover, there is every reason to believe that the great Keweenaw Series of Keweenaw Point belongs to this interval, though by no means filling it. This series, on the south shore of Lake Superior, lies unconformably beneath the same Cambrian sandstone which traverses the edges of the Lake Huron Huronian, while at the same time unconformable to rocks beneath it whose equivalence with the original Huronian there is every reason to accept, as is subsequently maintained in this paper.

[To be continued.]

ART. XXV.—*Ovibos cavifrons from the Loess of Iowa;* by W. J. McGEE.

A REMARKABLY perfect specimen of the extinct musk ox of North America has recently fallen into the hands of Prof. S. Calvin, of the Iowa State University. It was found in the loess of the Missouri River at Council Bluffs, Iowa, at a point 12 feet below the surface and 130 feet above the river. The bones collected comprise the larger part of the cranium with horn cores attached and some of the molars in place, about half of the lower jaw, the atlas, a femur, and a number of other bones in more or less fragmentary condition. The material has been placed in the cabinet of the State University at Iowa City.

This animal was introduced to science in this country by Dekay in 1828 under the name *Bos Pallassi;** it was more thoroughly investigated in 1852,† and the genus and species characterized in 1853,‡ by Leidy, under the provisional name *Bootherium cavifrons;* and in 1869 it was by the same author transferred to the genus *Ovibos.*§ At that time its remains were known from Fort Gibson, I. T., St. Louis, New Madrid, and Benton County, Mo., Trumbull County, Ohio, Big Bone Lick, Ky., and (probably) "the frozen cliffs of Eschscholtz Bay." The New Madrid specimen, which was the subject of Dekay's description, was thrown out of one of the earth-fissures formed during the great earthquake of 1811–13; and the adhering matrix indicated that it had been imbedded in pebbly and sandy clay containing considerable quantities of lignitized wood. The Fort Gibson specimen, which was Leidy's type, was reported to have come from a gravelly bluff of the Arkansas River, but had long been used as a seat "in the hut of an Indian."

The Council Bluffs discovery is significant in that it adds an important link to the already strong chain of evidence as to the climate of the loess period. Leidy expresses the opinion that *cavifrons* was clothed with a long fleece like that of its modern congener; and the occurrence of its remains in the loess is thus indicative of low temperature during the accumulation of this phase of the glacial deposits. The immediate associates of the Council Bluffs individual included the elephant and mastodon, at least one small rodent, paleolithic man according to Aughey,‖

* Ann. Lyc. Nat. Hist. N. Y., vol. ii, 280–91.

† Proc. Acad. Nat. Sci. Phil., vol. vi, 71.

‡ "Memoir on the Extinct Species of the American Ox," Smithsonian Contributions, vol. v, 12–17.

§ "The Extinct Mammalian Fauna of Dakota and Nebraska," etc., Journ. Acad. Nat. Sci. Phil., 2d ser., vol. vii, 374–5.

‖ Hayden's Ann. Rep. U. S. Geol. and Geog. Surv., for 1874, 254–5.

and several pulmoniferous mollusca, which are here of normal size and character, while at Des Moines, a hundred miles to the eastward, they are depauperate,* presumptively by reason of the frigid climate of that period. Under about the same latitude on the Mississippi the loess fauna includes the elephant† and the woodland reindeer (*Rangifer caribou*), or some closely allied species for which the alternative name *Cervus muscatinensis* has been suggested by Leidy,‡ together with several terrestrial and fresh water mollusca only slightly, if at all, depauperate; but within fifty miles to the northward, in Clinton County, Iowa, the loess shells are notably depauperate, and fifty miles further, in Dubuque County, they are exceedingly rare and reduced to a half or third, or even a fourth, of their normal linear dimensions.

This testimony of the fauna as to the temperature of the loess period is corroborated by that of the deposits themselves. At Des Moines the loess graduates downward into, and is moreover overlaid by, glacial drift; midway between Des Moines and the Mississippi River the loess merges into the underlying drift so imperceptibly that no line of demarkation can be drawn between them, and it is evident that the two represent merely different phases of the same deposit; much of the loess of eastern Iowa unquestionably consists of the mud of glacial streams, laid down in ice-bound lakes;§ and the Missouri River loess has been shown by N. H. Winchell to graduate into morainal drift in southwestern Minnesota,‖ just as is the case in southeastern Iowa.

It is noteworthy that while the Council Bluffs specimen comes from well within the glaciated area and the Big Bone Lick specimen from near its margin, the Missouri and Indian Territory specimens are from localities some three degrees beyond the limits of that area; and, although the data are too meagre to justify final conclusion, it may be inferred that the glacial refrigeration forced the Arctic fauna about that far beyond the ice margin, and that it was felt even farther southward. This inference is in harmony with the results of recent work in eastern United States. During the earlier epoch of Quaternary cold, the middle Atlantic slope was submerged to a depth of over three hundred feet, and its rivers—the Delaware, the Susquehanna, the Patapsco, the Potomac, the Rappahannock, the James, the Appomattox, and the Roanoke—built deltas at their embouchures into the expanded Atlantic along the inland margin of the Coastal Plain of to-day. A conspicu-

* This Journal, III, vol. xxiv, 1882, 215–219.
† Proc. Davenport Acad. Nat. Sci., vol. i, 1876, 196–9.
‡ Proc. Acad. Nat. Sci. Phil., vol. xxxi, 32–3.
§ Trans. Iowa State Hort. Soc. for 1883, vol. xviii, 328–39.
‖ Sixth Ann. Rep. Geol. and Nat. Hist. Surv. Minn., 1877, 104–6.

ous element in these deltas consists of the bowlders floated down in the ice floes of winter and spring, just as considerable masses of gneiss are now carried into the estuarine portions of the rivers by every spring freshet. Now in the Quaternary delta of the Susquehanna, the bowlders are at least fifty times as large as those brought down in the ice-blocks of the present; in the Patapsco and Potomac deltas, the Quaternary bowlders are twenty times as large as those of to-day; along the Rappahannock, the ancient bowlders are ten times as large as the modern; on the James and Appomattox, the old are five times larger than the new; and on the Roanoke the bowlders of the delta are twice or thrice as large as those of the modern alluvium. It would appear, accordingly, that the Quaternary refrigeration here extended as much as, yet but little more than, three or four degrees beyond the ice margin. The inference is fairly harmonious, too, with the conclusions already reached concerning the Quaternary climate of western United States. King,* Gilbert,† and Russell‡ have indeed shown that the refrigeration of the glacial time was felt fully ten degrees beyond the Cordilleran ice-margin; but in this region the effects of refrigeration were unquestionably cumulative, and the chief climatal effect was increased humidity and consequent expansion of the outletless lakes of the Great Basin, with comparatively slight increase in the local glaciers of the Sierras and on the peaks of the Wasatch, and (probably) with little diminution in the mean temperature.

The recent discovery is significant, also, in that it greatly extends the applicability of *cavifrons* as a criterion for correlating deposits of widely diverse genesis in widely separate localities. In their classic report on the Mississippi River, Humphreys and Abbot show that the so-called alluvium of the lower portion of that river consists mainly of a heavy deposit of hard blue or drab clay containing abundant carbonaceous matter, generally covered by a slight veneer of modern alluvium, and concluded that the deposit was formed "long antecedent to the present epoch."§ Hilgard designated this blue clay deposit Port Hudson,‖ observed that it was intercalated between the loess and the Orange Sand, and inferred that it was laid down during a period of submergence of the lower Mississippi region probably coincident with some later stage of the glacial epoch; and he specifically supported the opinion of the engineers as to its

* U. S. Geol. Expl. 40th par., vol. i. Systematic Geology, 1878, 461, analytic map v, 480–529.

† 2d Ann. Rep. U. S. Geol. Survey, 1882, 186–189.

‡ Geol. Hist. of Lake Lahontan, Monograph U. S. Geol. Survey, vol. xi, 261; and elsewhere.

§ Physics and Hydraulics of the Miss. River, 1876, 57–58, 91–95.

‖ This Journal, II, vol. xlviii, 1869, 332.

antiquity and distinctness from the alluvium proper.* Now the New Madrid specimen appears to have come from the Port Hudson beds; and the Fort Gibson specimen was obtained from a puzzling superficial deposit found in Missouri, southern Kansas, Indian Territory, Eastern Texas, and Arkansas, which is conspicuous along the water-ways but attenuates and frequently disappears over the higher lands, and which seems to be a slack-water deposit laid down in the waterways of the region during the Port Hudson submergence. The paleontologic correlation is therefore perfectly consonant with the physical, and the two lines of evidence are cumulative. The evidence of the fossils is of exceptional value, too, when, like *Ovibos* and *Rangifer*, they represent an arctic fauna; for not only are vertebrates the most sensitive time indicators, by reason of the evanescence of types, as shown by Marsh, but when the remains of arctic animals are found in temperate latitudes it is manifest that they indicate only a temporary incursion of the fauna, and therefore represent but a small portion of the period covered by the phylogeny of the species.

ART. XXVI.—*On the Chemical Composition of Howlite, with a note on the Gooch method for the determination of boracic acid;* by S. L. PENFIELD and E. S. SPERRY.

THIS interesting mineral was first identified as a new species by Prof. Henry How,† of Windsor, Nova Scotia, who named it silicoborocalcite, assigning to it the composition $2CaO . SiO_2 + 2(CaO_2 . BO_3 . HO) + BO_3 . 3HO$, written in the old system and in the form suggested by Prof. How. He described it as occurring in dense, chalk-like nodules in the gypsum beds at Brookfield, near Windsor, N. S. In later papers‡ he mentions its occurring in four distinct localities near Windsor, the nodules being sometimes as large as a man's head and composed of minute scaly and silky crystals. The name howlite was substituted for silicoborocalcite by Prof. J. D. Dana and used by him in the fifth edition of his System of Mineralogy.

The specimen which we have examined was collected in the gypsum quarries at Windsor, N. S., by Mr. Charles G. Rupert, of Minneapolis, Minn., who generously presented it to the mineralogical department for investigation. It consisted of an egg-shaped nodule about one and one-half inches in its greatest diameter, embedded in massive gypsum. The nodule was composed of intergrown microscopic needles which under the

* This Journal, III, vol. ii, 1871, 402.
† Phil. Mag., IV, xxxv. p. 32.
‡ Phil. Mag., IV, xxxvii. 270 and xxxix, 278.

microscope were resolved into flattened prismatic forms, having somewhat the shape of thin stilbite crystals, the largest 0·23 × 0·27 mm., usually broken at the extremities but occasionally terminated by two dome faces. In polarized light they showed parallel extinction, brilliant polarization colors, red and yellow of the first order, according to the thickness of the crystal, the longer axis being the axis of least elasticity. In convergent light an obtuse bisectrix was very indistinctly seen, the plane of the optic axes being at right angles to the longer axis of the crystal. The crystallization is therefore probably orthorhombic. Owing to the slight solubility of the mineral in water its specific gravity was taken in alcohol and found to be 2·59 referred to water. A sample was taken for analysis by breaking into the nodule and carefully freeing from adhering gypsum by hand picking, but it was impossible to obtain the borate perfectly pure, a little SO_3 being found on analysis which undoubtedly resulted from adhering gypsum. The results of analysis of the air-dry powder are as follows:

	I.	II.	Mean.
SiO_2	14·65	14·74	14·70
B_2O_3	42·68	42·70	42·69
CaO	28·22	28·19	28·20
Na_2O	·55	·47	·51
K_2O		·12	·12
H_2O	12·01	11·94	11·97
SO_3	1·93	2·10	2·01
			100·20

Below the results are given after deducting 4·32 per cent of gypsum corresponding to 2·01 per cent of SO_3, and calculating to 100·00 per cent together with the analysis of How and the theoretical percentages derived from our ratio.

		Ratio.		How.	Calculated for $H_6Ca_2B_5SiO_{14}$.
SiO_2	15·33	·255	2·00	15·25	15·31
B_2O_3	44·52	·636	5·00	[44·22]	44·65
CaO	27·94	·498		28·65	28·56
Na_2O	·53	·008	·507 3·99		
K_2O	·13	·001			
H_2O	11·55	·641	5·04	11·84	11·48
	100·00			100·00	100·00

The ratio of $SiO_2 : B_2O_3 : CaO : H_2O = 2 : 5 : 4 : 5$ very closely, with a small part of the CaO replaced by Na_2O and K_2O. This is exactly the ratio obtained by Prof. How, but the analysis is of importance as proving the identity of this curious boro-silicate as a distinct species, the original analysis having been made on dense chalk-like varieties and the most important con-

stituent, B_2O_3, being determined by difference. The air-dry powder of the mineral lost water slowly at 100° C. but soon came to a constant weight at 150° C. losing 0·83 per cent, the mineral suffering no further loss by heating to 360°. The loss of 0·83 per cent corresponds closely to 0·90 per cent, the amount of water contained in the 4·32 per cent of gypsum which the analyzed portion contained. Thus the loss of water at 150° C. as well as the SO_3 determination and the occurrence of the nodule in massive gypsum suggest that there was a slight impurity of gypsum in the material which was analyzed. The fact that the mineral does not part with its water at 360° C. indicates that the hydrogen is very firmly united in the molecule, probably as hydroxyl. The mineral is therefore a very acid silico-borate and its formula may be written $H_6Ca_2B_6SiO_{14}$, differing essentially from the more common silico-borates of calcium, datolite and danburite, in containing much less silica and more boracic acid, causing the mineral to be classified more naturally with the borates than with the silicates.

On igniting the mineral in a closed tube water is given off which reacts strongly for boracic acid with tumeric paper; the water in the above analysis was therefore obtained by ignition and absorption in a chloride of calcium tube. The boracic acid was determined by the admirable method suggested by Prof. F. A. Gooch.* The other constituents were determined by the usual methods.

2. *Note on the Gooch method for the determination of boracic acid.*

Before commencing the above analysis we carefully reviewed the method described by Prof. Gooch,† making a number of determinations of B_2O_3 in borax in order to become fully acquainted with the method. The distilling apparatus described by him proved very satisfactory. The boracic acid in our experiments was set free by nitric acid, distilled over with methyl alcohol and evaporated with a weighed quantity of ignited calcium oxide. Without the use of very large platinum crucibles the evaporation of the boric ether with slaked lime is attended with some difficulty. The calcium borate together with the excess of lime form as a thick crystalline precipitate at the bottom of the crucible and if the methyl alcohol boils during the evaporation some of the precipitate will be carried mechanically out of the crucible; then too the very strong ignition of the CaO necessary to bring it to a constant weight is not so readily accomplished if the crucibles are very large. The following method was found to give very good satisfaction and can be used by any one having an ordinary sized platinum crucible and preferably a platinum dish.

* Am. Chem. Journal, ix, p. 23. † Loc. cit.

The lime after being ignited to a constant weight and slaked is transferred to a large platinum dish and warmed with water till it becomes of a milky consistency; it is not necessary to remove all the lime from the crucible, the latter being put away and used later on. Strong ammonia is poured into the receiving flask of the distilling apparatus described by Gooch, and after conducting the distillation as directed the contents of the receiver are poured into the platinum dish containing the slaked lime, water being freely used in rinsing out the receiver. The dish is then placed on a triangle over the water bath or otherwise gently heated till the volatile products, methyl alcohol and ammonia, are driven off, which by boiling might cause mechanical loss. When these are removed the contents of the dish can be evaporated to dryness. The dried calcium borate and the excess of lime are now transferred to the crucible in which the lime was weighed, this being easily accomplished by moistening the contents of the dish with water and shoving the bulk of the precipitate into the crucible with a spatula, by rinsing with a little water and by using a rubber on the end of a glass rod all but a very little of the borate and lime can be transferred to the crucible; that which sticks too firmly to the dish can be dissolved in one or two drops of dilute nitric acid which is brought in contact with all parts of the dish with the rubber; the solution is then transferred and rinsed into the crucible. The transfer and washing can readily be made by using not over 30 cc. of water which can be contained in an ordinary student's crucible. The evaporation from this point goes on very simply, the borate drying out nicely on the water-bath. By placing the platinum crucible in a large porcelain one and gradually raising the heat to strong ignition the borate may be further dried out without any danger of snapping. The residue is finally ignited over the blast lamp till a constant weight is obtained.

In slaking the lime we have found it convenient not to add the water directly to the ignited lime, causing danger from excessive heating and mechanical loss, but to place the open crucible on a watch glass containing water and covered with a bell jar: in this way the lime soon slakes and in case of special hurry hot water may be placed in the watch-glass from time to time so that the atmosphere under the bell jar will be thoroughly saturated; in this way the lime will become so thoroughly slaked in one or two hours that there will be no danger of excessive heating on further addition of water.

The following results were obtained using in all cases about one gram of crystallized borax and one gram of lime: B_2O_3 in borax 36·55, 36·42, 36·58, 36·64, calculated 36·64 per cent.

Mineralogical Laboratory,
Sheffield Scientific School, April 14, 1887.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a Vapor-calorimeter.*—Bunsen has described a new calorimeter based on the principle, first employed by Joly, of using the condensation of saturated water-vapor of constant temperature as the calorimetric measure. Having carefully studied the problem, the author has confirmed the practicability of the method, and has constructed an instrument in which the principal difficulties are entirely overcome. The body whose specific heat is desired is placed in a platinum basket and suspended in the vapor of boiling water. The water which is condensed during the heating of the body, is retained in the basket and can be weighed provided the weighing is done in the vapor. From the weight thus obtained, since the latent heat of condensation of water-vapor is known, the amount of heat absorbed by the body in raising its temperature through the given number of degrees may be calculated.—*Ann. Phys. Chem.* II, xxxi, 1; *Ber. Berl. Chem. Ges.*, xx, 275 (Ref.), May, 1887. G. F. B.

2. *On the density of liquid Methane, Oxygen and Nitrogen.*—By the use of his apparatus, Olszewsky has been able to obtain 13 to 15 c.c. of any desired gas in the liquid condition, cooled by boiling ethylene and liquefied by pressure. The liquid is collected in a double glass tube, and when freed from external pressure, the exterior layer evaporates first under the influence of the relatively warmer ethylene, while about 4 or 5 c.c. of the substance remains in the inner tube cooled in this way to its own boiling point. This portion of liquid is thoroughly protected against the access of heat, and can evaporate therefore only with proportionate slowness. At a given moment its volume may be read off on a scale engraved on the glass tube in which it is contained. Its mass may easily be determined from the amount of gas given by its evaporation; and from these data the density of the liquid is readily calculated. The densities of methane, of oxygen, and of nitrogen thus found are as follows, at the temperature of their boiling points:

	Density.	Boiling point.
Methane,	0·415	−164·0°
Oxygen,	1·124	−181·4°
Nitrogen,	0·885	−194·4°

—*Ann. Phys. Chem.* II, xxxi, 58; *Ber. Berl. Chem. Ges.*, xx, 276 (Ref.), May, 1887. G. F. B.

3. *On the experimental demonstration of Avogadro's Hypothesis.*—Schall has constructed a balance so that the ratio of the density of any given gas to that of hydrogen—and hence the molecular weight of this gas—may be read directly from the deflection. Two glass globes are provided, the capacities of which are as nearly equal as possible, and whose weights are equalized by means of a suitable counterpoise. The balance carries a combined

scale, consisting of an upper fixed part graduated according to the tangent of the deflection-angles, and of a lower part placed behind the former and movable vertically. If one of the two equilibrated globes be exhausted, or if, what is the same thing, the weight of air which it contains be calculated from its capacity and this weight be added to the globe full of air, a deflection-angle will be obtained whose tangent is proportional to this excess of weight. If now the same globe be filled with a given gas, a second deflection-angle will be obtained whose tangent will be proportional to the algebraic sum of the weight of the air and the excess of weight of the gas. Hence, the tangent of the sum of the two deflection-angles is proportional to the weight of the gas. It is necessary, therefore, only to divide this tangent into as many parts as there are units in the molecular weight of the gas employed. The movable scale can therefore be empirically adjusted either with a pure gas or by means of the corresponding weight. Since, however, the sum of the deflection-angles is a function of the temperature and pressure, it is necessary of course to adjust the movable part of the scale for the given conditions. —*Ber. Berl. Chem. Ges.*, xx, 1433, May, 1887. G. F. B.

4. *On the Evolution of Sulphurous oxide and of Oxygen in Kipp's Apparatus.*—NEUMANN has extended the use of Kipp's apparatus for the ready evolution of gases, first suggested by Winkler for chlorine. For sulphurous oxide, he proposes a mixture of three parts calcium sulphite and one of gypsum made into cubes, as in Winkler's method. These cubes are placed in the middle bulb of an ordinary Kipp's apparatus and crude concentrated sulphuric acid is made to act on them. Half a kilogram of cubes yielded the author a constant current of gas for thirty hours. They remained unaltered in shape, no gypsum falling to the bottom of the vessel. It is desirable to moisten no more of the cubes than is necessary to produce the amount of gas required. The evolution of oxygen in this way is effected by the use of cubes made of a mixture of two parts barium peroxide, one part manganese peroxide and one part gypsum. The evolution of the oxygen is produced by means of hydrogen chloride solution of a specific gravity of 1·12 diluted with an equal quantity of water. In the reaction there is evolved beside the oxygen a little chlorine; and hence it is necessary to wash the gas in an alkali solution, as is the case with the oxygen which is evolved by heating potassium chlorate.—*Ber. Berl. Chem. Ges.*, xx, 1584, June, 1887. G. F. B.

5. *On the Vapor-density of Tellurium tetrachloride and on the Valence of Tellurium.*—Of the elements of the sulphur group, no compounds are known, permanent in the state of vapor, in which for each atom of the element there are more than two of a univalent radical. The compounds SCl_4, $SeCl_4$ and $TeCl_4$ are known, it is true, but the first is permanent even in the liquid state, only at −21°, and the second decomposes at 218°, yielding a vapor desity of 3·922 instead of 7·63; being broken up into selenium

dichloride and free chlorine. MICHAELIS has undertaken a study of tellurium tetrachloride, the vapor density of which has not thus far been determined. On preparing this substance the author found that it was much more volatile than the books stated, and that it boiled constantly at 380°. For its production a flask was employed somewhat similar to that which is used for distilling liquids in indifferent gases, but in which the lateral exit tube for the vapor was widened to avoid obstruction by the solid chloride formed. This lateral tube passed into the vertical tube of a second similar flask, the chloride distilling directly from one of these flasks to the other. On admitting the chlorine and gently heating, the tellurium passes first into the dichloride, which is dark brown when fused and gives a dark red vapor, and then with considerable increase of volume into the tetrachloride. This when fused is amber yellow and gives a vapor of the same color, but solidifies into a colorless, crystalline and very deliquescent mass. By a second distillation in a current of chlorine, it was entirely freed from the dichloride. Redistilled in carbon dioxide gas, it boiled constantly at 380°, and its analysis agreed closely with the formula $TeCl_4$. The vapor density was determined by Victor Meyer's method, the apparatus being filled with dry nitrogen, and great care being taken to avoid the presence of moisture. In sulphur vapor at the temperature of 448°, two determinations gave the values 9·028 and 9·224; the calculated value from the formula being 9·32. In the vapor of phosphorus pentasulphide at 530°—and therefore 150° above the boiling point of the tetrachloride—the values 8·859 and 8·468 were obtained. Hence it appears that tellurium tetrachloride does not suffer decomposition even at this temperature, thus resembling the analogous chlorides of tin, of silicon and of titanium; and moreover that its formula in the state of vapor is actually $TeCl_4$. The author regards it as proved, therefore, that tellurium has certainly a valence as high as four; and from its analogies with sulphur and selenium that this fact is probably also true of these elements.—*Ber. Berl. Chem. Ges.*, xx, 1780, June, 1887. G. F. B.

6. *On Diamide* (*Hydrazine*).—When diazoacetic ether is treated with hot concentrated solution of potassium hydrate, CURTIUS has observed the formation of a new diazo-fatty acid. The potassium salt is distinguished from previously described diazo-compounds by the fact that the diazo-acid set free from it by the addition of a mineral acid is not decomposed with the evolution of nitrogen, but separates in gold yellow scales. If an aqueous solution of this diazo-acid be digested a short time with very dilute sulphuric acid, it becomes colorless without evolving gas, and the solution on cooling deposits a colorless and magnificently crystalline body. This substance is the sulphate of the long sought diamide (hydrazine) $H_2N \cdot NH_2$. In consequence of its slight solubility in water it is easily obtained pure. On warming its salts with alkali solution, diamide is set free as a permanent gas, possessing a very peculiar odor, scarcely recalling that

of ammonia, but strongly attacking the mucous surfaces when breathed. The gas is very readily soluble in water, blues reddened litmus paper strongly, and when not too dilute produces white fumes with hydrogen chloride. It is exceedingly permanent on heating, but has a powerful reducing action. Fehling's solution and ammoniacal solution of silver are at once reduced, and neutral copper sulphate yields a dense red precipitate with it. Mercuric chloride is reduced by it to mercurous chloride. Its salts evolve gas actively when mixed with nitrites. —*Ber. Berl. Chem. Ges.*, xx, 1634, June, 1887. G. F. B.

7. *Method of observing the action of Magnets on Liquids;* by S. T. MOREHEAD.—Some weeks ago one of my students, Mr. J. C. Child, and myself were working with a diamagnetic instrument, simply repeating well known experiments. Plücker's method of observing the diamagnetism of liquids having failed in our hands to give satisfactory results, we hit upon a method which was new to us and which was very satisfactory. Into a glass tube of about four or five millimeters internal diameter a small quantity of liquid was introduced forming a short cylinder. This tube was placed horizontally at right angles to the line joining the poles of the magnet with the liquid nearly between the poles. When the current was turned on, the liquid was very evidently repelled. Water was repelled through a distance of about half a centimeter; wood spirit through a greater distance. By moving the tube in the direction of its length the wood spirit could be pushed any distance through the tube. The amount of motion is of course a function of the resistances due to adhesion and friction as well as of the repulsive force. The attraction of liquids is easily shown by the same method.

A single modification of the above plan of proceeding is to incline the tube slightly so as to make the liquid flow toward the poles. If the required velocity be not too great the magnet acts as a break to stop the motion. It is well to bend the tube up a little at each end to prevent the liquids from flowing out. This method is well adapted for projection so as to be seen by large audiences.

Washington and Lee University, Lexington, Va., May 9, 1887.

8. *Comparison of the radiations from melting platinum and silver.*—M. J. VIOLLE has studied these radiations by means of a thermopile, one surface of which received the radiations and the other was exposed to a known source of heat in such a manner as to bring the needle of the galvanometer to zero. It was found that the total radiation of melting platinum is fifty-four times that of melting silver.—*Comptes Rendus*, July 18, 1887, p. 163. J. T.

9. *Solidification of liquids by pressure;* M. E. H. AMAGAT has succeeded in solidifying bichloride of carbon (C_2Cl_4) by pressure. The disposition of his apparatus enabled him to photograph the resulting crystalline body. C_2C_4 solidifies under the following conditions.

At 19°·5 under pressure of 210 atmospheres.
" 0· " " " 620 "
" 10· " " " 900 "

M. Amagat suggests that there may be for each liquid a temperature above which solidification cannot take place under any pressure: that is to say, a critical point of solidification.—*Comptes Rendus*, July 18, 1887, p. 165. J. T.

10. *The Conductibility for heat of Bismuth in the magnetic field.*—M. A. RIGHI announces that the heat conductibility of bismuth varies in a magnetic field. In other words, that a rotation of the isothermals analogous to the Hall phenomenon takes place. —*Comptes Rendus*, July 18, 1887, p. 168. J. T.

11. *Size of the Silver Molecule.*—In an exhaustive paper upon methods of measuring thin films, OTTO WIENER makes certain measures of the thickness of a film of silver which can just be perceived by the eye, and arrives at the conclusion that 0·2 millionths of a millimeter is an upper limit of the diameter of a silver molecule.—*Annalen der Physik und Chemie*, No. 8ª, 1887, pp. 629–672. J. T.

12. *Changes in the Ohm.*—HIMSTEDT has repeatedly re-measured certain standards constructed of german silver and has discovered that, independent apparently of changes of temperature, the resistance of german silver undergoes a slight change. He calls attention to the custom of Messrs. Siemen and Halske of keeping their german silver wire six months after it is covered and wound before it is used for electrical standards of resistance. The experiments of Himstedt supports this procedure of the manufacturers, although no reason is assigned for it. It is better, therefore, to compare with a mercury standard, although the extent of the change of the german silver standards is too small to affect their use in the arts.—*Ann. der Physik und Chemie*, No. 8ª, 1887, p. 617. J. T.

13. *The Chemistry of the Sun;* by J. NORMAN LOCKYER. 8°, pp. xix and 457. Macmillan & Co., London, 1887.—The prime object of this volume is to set forth the theory of dissociation which Mr. Lockyer propounded many years ago, together with the various researches which he has himself carried on to test the theory, and also to show what bearing the investigations and observations of other scientists have upon the same. The earlier chapters of the book are preliminary and are devoted to a history of the work done upon the solar spectrum previous to the last twenty years; the rest of the work is a rehearsal of later work, and a comparison of the theory with facts.

Mr. Lockyer's theory is thus stated (p. 260): "chemists regard matter as composed of atoms and molecules. The view now brought forward simply expands the series into a larger number of terms, and suggests that the molecular grouping of a chemical substance may be simplified almost without limit if the temperature be increased." The earlier hypothesis of the structure of the solar atmosphere and that propounded by Mr. Lockyer he thus contrasts (p. 303). On the old hypothesis:

(1.) We have terrestial elements in the sun's atmosphere.

(2.) They thin out in the order of vapor density, all being represented in the lower strata, since the temperature of the solar atmosphere at the lower levels is incompetent to dissociate them.

(3.) In the lower strata we have especially those of higher atomic weight, all together forming a so-called "reversing layer" by which chiefly the Fraunhofer spectrum is produced.

The new hypothesis changes these to:

(1.) If the terrestrial elements exist at all in the sun's atmosphere they are in process of ultimate formation in the cooler parts of it.

(2.) The sun's atmosphere is not composed of strata which thin out, all substances being represented, at the bottom; but of true strata, like the skins of an onion, each different in composition from the one either above or below.

(3.) In the lower strata we have not elementary substances of high atomic weight, but those constituents of the elementary bodies which can resist the greater heat of these regions.

Mr. Lockyer discusses at length the variations of spectral lines which are usually regarded as belonging to iron, calcium and other chemical elements, as they appear in the solar spectrum, the solar prominences, the electric spark, the electric arc and the Bunsen flame. In this comparison of spectra of matter presumably at different temperatures he finds support for his new theory. Also from seven series of solar spots each series containing 100 spots, observed mainly by his assistants Messrs. Lawrance and Greening, between 1879 and 1885 he obtains like arguments. Additional arguments are obtained from a detailed discussion of the prominence lines, and from the spectra of the corona seen during eclipses. H. A. N.

14. *Joint Scientific Papers of James Prescott Joule.* Published by the Physical Society of London. 391 pp. 8vo. London, 1887. (Taylor and Francis).—The first volume of the papers by Dr. Joule, republished by the London Physical Society, was noticed in volume xxviii of this Journal. The present volume will be also welcome to physicists. It includes a short paper on experiments and observations on the mechanical powers of electro-magnetism, steam and horses, by Dr. Joule and Dr. Scoresby; a series of papers on atomic volume and specific gravity, and another series on the relation in volumes between simple bodies, their oxides and sulphurets, etc., by Dr. Joule and Sir Lyon Playfair; finally a series of papers by Dr. Joule and Sir Wm. Thomson, on the thermal effects of fluids in motion.

II. Geology and Mineralogy.

1. *Note on the Characters and Mode of Formation of the Coral Reefs of the Solomon Islands, being the results of Observations made in* 1882–84; by H. B. Guppy, M.B., F.G.S., during the surveying cruise of H. M. S. "Lark."—Mr. Guppy describes the coral reefs of the Solomon Islands with fulness and much val-

uable detail. After presenting the facts as to various reefs, and the depths of the living corals, the limit of which he finds to be beyond thirty fathoms, he presents his conclusion with regard to the origin of the barrier reefs. He observes that, after coral reefs have begun about an island, the detritus, made from the corals, will collect in a band on the outer slope of the reef, at depths near the limit usually attributed to growing coral, and extend, as may be determined, by the presence, position and slope of the declivities. In such a zone of detritus the corals do not thrive. But below it the slopes may be gentle again, and there may be another zone of corals; and when so, the corals of this outer zone may rise and make a surface reef, separate from the first or fringing reef by a region of detritus; the outer reef so made will be a barrier reef. An elevation in the region may bring other parts of the sea-bottom about islands within coral reef depths, and thus the process may be repeated and extended. The objection to the theory that the depths inside of barrier reefs are sometimes forty to sixty fathoms is met on the ground of the possibility that the lower coral reef limit may be as great as this, and on his own observation that "off the reef of Choiseul Bay I did not seem to have reached the lower limit in soundings of forty fathoms." Mr. Guppy states that his views are substantially the same with those of Prof. Joseph Le Conte, as presented in his paper on the Florida barrier reefs (this Journal, II, xxiii, 46). Mr. Guppy gives other conclusion from his observations.

What is needed to place the subject entirely above the level of hypothesis is a series of generous borings in several atolls and barrier reefs, as the writer has elsewhere suggested. It is not a question, merely, as to how reefs have been made, but whether or not great downward as well as upward change of level is possible in Quaternary or recent times within the oceanic limits, and it therefore calls for whatever expenditure may be necessary to carry on such borings effectually. J. D. D.

2. *Explorations in Florida;* by ANGELO HEILPRIN, 134 pp., large 8vo, with 20 plates. Philadelphia. *Transactions of the Wagner Free Institute of Science of Philadelphia.* Published under the direction of the Faculty, May, 1887.—The Wagner Free Institute of Science in Philadelphia, was founded by the late WILLIAM WAGNER, of that city, and sustained as an Institute of free lectures by his annual gifts for thirty years; and at his death, in January, 1885, all his property was bequeathed to it. The faculty consists of four professors with Dr. Leidy as the president. The trustees have appropriated part of the fund to aid in original research, and the memoir of Mr. Heilprin is the first of the reports thus obtained.

The expedition to Florida was organized early in 1886, with the generous coöperation of the Academy of Natural Sciences and Messrs. Joseph Willcox and C. H. Brock, who joined it, Mr. Heilprin being put in scientific charge. The schooner Rambler was chartered for the excursion.

Mr. Heilprin's report describes the features of the region visited, its geology, and its paleontology, besides making some contributions to its zoology. Seventeen of the twenty plates are covered with admirable autoglyphic figures of the fossils; and besides these, the snake *Tropidonotus taxispilotus* is figured on plate 17; the fish *Ictalurus Okeechobeënsis* on plate 18, and the new species of Aplysia, *A. Willcoxi*, on plate 19.

A history of former geological investigations in Florida is given which includes a notice of Conrad's identification of the Vicksburg Tertiary at Tampa Bay; an account of the work of Dr. E. A. Smith, geologist of Alabama, who found a considerable part of the northern half of Florida to be underlaid by a fossiliferous limestone, whose fossils were studied by Mr. Heilprin and referred to the Oligocene, and found to include, besides great numbers of *Orbitoides complanata*, the first then recognized of American Nummulites, named *N. Willcoxi;* and Dr. J. C. Neil's discovery of Mammalian remains, near Archer, in Alachua county, Florida, among which Dr. Leidy recognized species of Mastodon, Rhinoceros, Tapir, Horse, Llama, Camel and Hog. The results of the explorations made are then given, with the following general conclusions.

The surface rocks of Florida are exclusively Tertiary and Quaternary. No observed facts sustain the coral theory of formation propounded by Agassiz; on the contrary, they prove that the coral tract of Florida is confined to a border region on the south and southeast; that the few fossil corals found in Tertiary deposits are sporadic growths, not parts of reef formations. The formations represented are the Oligocene, Miocene, Pliocene and Postpliocene, which, commencing with the oldest at the north, follow one another in regular succession from north to south, thus clearly indicating the course of progress in the growth of the Peninsula. The successive belts are not directly east and west in course, but to the eastward are deflected northeastward so as to conform approximately to the Atlantic border. No Eocene rocks were found, but such may exist in the northern section of the State, and possibly they may comprise part of what is called Oligocene. The different formations are horizontal or very nearly so; and they follow one another without any broad or distinct lines of faunal separation. The northern half of Florida appears to be covered with a deep-sea formation, and the southern with beds made in a comparatively shallow sea. The elevation of the area, especially the southern part, went on very gradually, without leaving any marks of disturbance. Before the elevation was completed, a large part, especially the southern, was a submerged flat or plain, the shallow coverings which were favorably situated for a profusion of animal life, and "the accumulation of reef structures and of vast oyster and scallop banks;" and freshwater streams existed as is proved by the commingling of marine and fluviatile mollusks in the deposits of the Caloosahatchie. The derivation of the modern species of the coast from older Florida species is easily traced out.

Portions of a skeleton of man, including an entire head, were formerly obtained near Sarasota Bay, at a locality known as Mrs. Hanson's, from a partially indurated sandstone, and fragments including a vertebra were found by Mr. Heilprin. No fossils were found in the deposit to indicate its precise age.

3. *The summit-plates in Blastoids, Crinoids and Cystids and their Morphological relations;* by CHARLES WACHSMUTH and FRANK SPRINGER. Proc. Acad. Nat. Sci. Phil., March 29th, 1887. pp. 33 and one plate.—This paper is chiefly devoted to a criticism of certain views expressed by Etheridge and Carpenter in their recently published catalogue of the Blastoidea in the Geological Department of the British Museum, with regard to the morphological relations of the summit-plates in the three groups mentioned in the above title. Etheridge and Carpenter argue that the six proximal plates surrounding a central one in the summit of typical Blastoids and Palæocrinoids are the homologues of the five oral plates in Neocrinoidea, and that in both cases they may be traced by a series of parallel transitions from a simple form of summit consisting of only five plates. Wachsmuth and Springer undertake to prove by a critical analysis of the forms relied upon by Etheridge and Carpenter, based on material in an excellent state of preservation, that their assumed simple form does not exist at all in the Blastoids. Further, that the Palæocrinoids, such for example as Haplocrinus and Allagecrinus, bearing the simple form of five plates on the ventral side, do not present analogous cases. Their theory, Wachsmuth and Springer contend, wholly fails to show any valid homology for the central summit plate inside the proximal ring in Palæocrinoids, (which covers the actinal center, just as the orals do in Neocrinoids) but requires the assumption of an "orocentral" plate; thus introducing an element in Echinoderm morphology which is altogether unrepresented in other echinoderms. They claim that before the homology proposed by Etheridge and Carpenter can be accepted they must show by what developmental process the five oral plates are transformed into six proximals, especially in cases where they are not modified by anal structures. Also that they must demonstrate the existence of their hypothetical "orocentral." The plate of illustrations consists of diagramatic figures of the forms of summit mentioned in the discussion. C. A. WHITE.

4. *Cliftonite, a cubic form of graphitic carbon.*—The meteoric iron found in the district of Youndegin, West Australia, in 1884, has afforded an interesting form of carbon resembling graphite but in cubic form; this is described by FLETCHER in a recent number of the *Mineralogical Magazine.* Four fragments of the iron were found, the largest weighing $25\frac{3}{4}$ pounds; in addition there were a number of pieces aggregating 17 pounds, consisting essentially of the magnetic oxide of iron, doubtless due to the weathering of the original mass. The iron has a specific gravity of 7.85. It is very hard and contains numerous enclosures of

schreibersite; it does not yield distinct figures when etched. An analysis afforded:

Fe	Ni	Co	Cu	Mg	P	S	Insol. cubes.
92·67	6·46	0·55	tr.	0·42	0·24	none	0·04 = 100·38

The cubic crystals, obtained from dissolving a piece of the iron, were about a hundred in number, the average thickness of the larger ones being one-hundreth of an inch. The cubic faces predominate, but the edges in some cases are replaced by dodecahedral planes. The hardness is 2·5, the specific gravity 2·12, the color black. A series of chemical tests led to the conclusion that the material was carbon, resembling graphite in most of its characters but considerably harder and unlike in form. The author recalls a paper by Haidinger, published in 1846 on "Graphite pseudomorphous after iron pyrites" obtained from a graphite nodule in the Arva meteoric iron, and concludes that their nature must have been the same as those from the Youndegin iron. The pyrite hypothesis, however, is shown to be untenable as well on crystallographic grounds, as because pyrite is thus far an unknown mineral in meteorites. In some respects the Youndegin crystals suggest pseudomorphs, more especially since they sometimes consist simply of a hollow shell, but in other regards they appear to be original forms. The author is inclined to hold them to be an allotropic form of carbon distinct from diamond and graphite, and he names it Cliftonite after Mr. R. B. Clifton, Professor of Physics at Oxford.

III. Miscellaneous Scientific Intelligence.

1. *The Height of Summer Clouds.*—A knowledge of the heights and movements of the clouds is of much interest to science, and of especial importance in the prediction of weather; the subject has therefore recieved much attention during recent years from meteorologists, chiefly in this country and in Sweden. In the last published Report of the Meteorological Council for 1885–86 will be found an account of the steps taken by that body to obtain cloud-photographs; and in the *Meteorologische Zeitschrift* for March last, Ekholm and Hagström have published an interesting summary of the results of observations made at Upsala during the summers of 1884–85. They determined the parallax of the clouds by angular measurements made from two stations at the extremities of a base of convenient length, and having telephonic connection. The instruments used were altazimuths, constructed under the direction of Prof. Mohn, specially for measuring the parallax of aurora borealis. A full description of these instruments and of the calculations will be found in the *Acta Reg. Soc. Sc. Ups.* 1884. The results now in question are based upon nearly 1500 measurements of *heights;* the *motions* will form the subject of a future paper. It was found that clouds are formed at all levels but that they occur most frequently at certain elevations or stages. The following are,

approximately, the mean heights, in feet, of the principal forms: —Stratus, 2000; nimbus, 5000; cumulus (base), 4500, (summit) 6000; cumulo-stratus (base), 4600; "false-cirrus" (a form which often accompanies the cumulo-stratus), 12,800; cirro-cumulus, 21,000; cirrus, 29,000 (the highest being 41,000). The maximum of cloud-frequency was found to be at levels of 2300 and 5500 feet. Generally speaking, all the forms of cloud have a tendency to rise during the course of the day; the change, excepting for the cumulus-form, amounting to nearly 6500 feet. In the morning, when the cirrus clouds are at their lowest level, the frequency of their lowest forms—the cirro-cumulus—is greatest; and in the evening, when the height of the cirrus is greatest, the frequency of its highest forms—the cirro-stratus—is also greatest. With regard to the connection between the character of the weather and the height of the clouds, the heights of the bases of the cumulus are nearly constant in all conditions. The summits, however, are lowest in the vicinity of a barometric maximum; they increase in the region of a depression and attain their greatest height in thunderstorms, the thickness of the cumulo-stratus stretching sometimes for several miles. The highest forms of clouds appear to float at their lowest levels in the region of a depression. The forms of clouds are identical in all parts of the world, as has been shown in papers lately read by the Hon. R. Abercromby before the English and Scottish Meteorological Societies.—*Nature* xxxvi, 206.

2. *American Association for the Advancement of Science.*—The thirty-sixth meeting of the Association was held in New York City during the week from August 10th to August 16th, in the buildings of Columbia College. The meeting opened with an address of welcome from Rev. F. A. P. Barnard, President of the institution which had offered hospitality to the members of the Association, to which the President, Professor S. P. Langley, replied. The opening addresses before the Sections by their Vice-Presidents were as follows: Section B, W. A. Anthony, on the importance to the advancement of physical science of the teaching of physics in the public schools; Section C, A. B. Prescott, on the chemistry of nitrogen as disclosed in the constitution of the Alkaloids; Section D, E. B. Coxe; Section E, G. K. Gilbert, on the work of the International Congress of Geologists; Section F, W. G. Farlow, on vegetable parasites and evolution; Section H, D. G. Brinton, on a review of the data for the study of the prehistoric chronology of America; Section I, H. E. Alvord, on economy in the management of the soil.

In the evening of the opening day the retiring President, Professor Edward S. Morse delivered an able address upon Evolution. A lecture by Professor Henry Drummond of Glasgow, on the Heart of Africa, giving observations on a recent scientific tour to the region of the Zambesi and Lake Tanganyika, was listened to by a large and interested audience on Monday evening.

The list of papers accepted is given below; some of them were

followed by a prolonged and interesting discussion, as for example those devoted to the food question before Section I. The Geologists gave up the working part of Friday to a consideration of the Report of the American Committee of the International Congress of Geologists. The whole ground was gone over with care and it may be hoped that the discussion will lead to good results; the same topic had formed the subject of Mr. Gilbert's address before Section E, as noted above.

The following committees were appointed at the last day of the meeting: E. D. Cope, J. R. Eastman and G. K. Gilbert, a committee to devise methods of obtaining from Congress a reduction of the tariff on scientific books; Miss A. C. Fletcher and Mrs. T. Stephenson, a committee to petition Congress to take the necessary steps to preserve the archæological monuments on the public lands of the United States. A resolution was passed recommending the publication by the Government of an index to the literature of meteorology, now being prepared by Prof. Cleveland Abbe. Another resolution urged President Cleveland to appoint at once a permanent Superintendent of the United States Coast and Geodetic Survey. A third petitioned Congress to provide a Bureau of Standards, by which accurate standards of measure should be established for electricity, heat and light, and arrangements made for the issue of authenticated copies of the same.

The entertainment of visitors was under the charge of several local committees, to whose activity the success of the meeting was largely due. There was a general reception to the Association by the Ladies' Committee in the Metropolitan Opera House on Thursday evening; another reception was given by the Academy of Sciences and several others of less general nature. There were a number of excursions: around New York harbor, to Long Branch by boat, to West Point, and others which need not be particularized.

The next meeting of the Association was appointed for the fourth Wednesday of August, 1888, at Cleveland, Ohio. The President elected for this meeting is Major J. W. Powell; and the Vice-Presidents by sections—Mathematics and Astronomy, Ormond Stone; Physics, A. A. Michelson; Chemistry, C. E. Monroe; Mechanical Science, C. M. Woodward; Geology and Geography, G. H. Cook; Biology, C. V. Riley; Anthropology, Charles C. Abbott; Economic Science and Statistics, C. W. Smiley.

List of Papers accepted for Reading.

SECTION A.—*Mathematics and Astronomy.*

F. N. WILLSON: A completed nomenclature for the principal roulettes.

J. E. KERSHNER: Coefficients of collimation and flexure of transit instruments with broken tubes.

J. R. EASTMAN: The effect of some peculiarities of personal equation.

HENRY FARQUHAR: Variation of personal equation; a criticism.

HENRY B. FINE: The geometric meaning of singular solutions of differential equations of the second and higher orders.

WILLIAM HARKNESS: The visibility of objects as conditioned by their magnitude and brightness, with application to the theory of telescopes.

J. M. SCHAEBERLE: The horizontal flexure of a meridian circle.

ALEX. MACFARLANE: The logical theorems required in elementary geometry. The logical form of geometrical theorems.

J. A. BRASHEAR: A new form of comet seeker. Method of preventing breakage in the polarizing helioscope. Standard dimensions in astronomical and physical instruments.

F. H. BIGELOW: The phenomena of solar vortices.

LEWIS BOSS: A list of stars with large proper motions.

HENRY M. PARKHURST: Photometric observation of asteroids.

J. BURKITT WEBB: Moment of inertia.

R. S. WOODWARD: Method of computing the secular contraction of the earth.

ORMOND STONE: The orbit of Hyperion.

T. C. MENDENHALL: The eccentricities of guessing.

SECTION B.—*Physics.*

L. E. BLAKE: A method of telephonic communication between ships at sea.

J. J. SKINNER: A method of comparing galvanometer coils.

A. A. MICHELSON and E. W. MORLEY: A method for making the wave length of sodium light the actual and practical standard of length. The relative velocity of the earth and the luminiferous ether.

WM. A. ROGERS: Determination of the invariability of the coefficients of expansion of Bailey's metal, of Jessup's steel, and of Chance & Sons' glass, between the limits of $-3°$ and $+97°$ F. Description of a combined chronograph and weight motor. A method of obtaining the constant of gravity from the comparison of musical notes. Time of exposure and mass considered as functions of the rate of saturation of heat in the case of mercury and water. The definition of the Ohm by the equation $R=K\frac{C}{S}$. Determination of the coefficient of expansion of the glass plates used for stellar photography at Cordoba in the years 1872–1875 and 1879–1883. A study of thirty-two mercurial thermometers under variations of temperature between $-25°$ F. and $+95°$ F.

E. E. RIES: The electric current as a means of increasing the tractive adhesion of railway motors and other rolling contacts.

A. MACFARLANE: Notation for physical units.

C. LEO MEES: Experimental determinations of minimum wind-velocity in Washington, O., tornado.

H. S. CARHART: The simultaneous measurement of the speed of an engine and dynamo by electric means.

T. C. MENDENHALL and A. L. MCRAE: The electrical condition of the atmosphere in fair weather and during thunderstorms.

D. B. BRACE: A method of examining magnetic double circular refraction. The transparency of the ether and its possible viscosity.

W. M. DAVIS: A classification of the winds.

W. F. MAGIE: Measurement of surface tension of liquids.

WM. THOMSON: Color blindness of railway employees.

DEVOLSON WOOD: Gravitation ether. Second law of thermodynamics.

C. E. MONROE: Certain phenomena produced by the explosion of gun cotton on metallic plates.

A. B. JOHNSON: The difficulty of determining the direction of the source of sound of fog signals at sea.

J. BURKITT WEBB: A new dynamometer (with working model). Experimental determination of the reaction of a liquid jet. Experiments on the viscosity of oil. A new viscosimeter.

E. L. NICHOLS and W. S. FRANKLIN: The electromotive force of magnetization.

H. E. ALVORD: Influence of topography upon rainfall; from observations on Houghton Farm during 1884.

M. A. VEDER: Is terrestrial magnetism concerned in atmospheric movements?

T. A. EDISON: The pyromagnetic dynamo: a machine for producing electricity directly from fuel. A magnetic bridge or balance for measuring magnetic conductivity.

P. H. VAN DER WEYDE: A peculiar form of undulatory current suited to telegraphing on telephone circuits. Some notes on standard cells.

C. F. DE LANDERO: A relation between the quantities of heat combination in aqueous solution.

E. B. ELLIOTT: The mutual action of the elements of an electric current.

CLEVELAND ABBE: The Signal Service bibliography of meteorology.

SECTION C.—*Chemistry.*

FREDERICK B. POWER and HENRY WEIMAR: The constituents of wild cherry bark.

L. M. NORTON: The fatty acids of the drying oils.

H. W. WILEY: The chemical composition of the juices of sorghum cane, in relation to the production of sugar.

WILLIAM P. MASON: Percentage of ash in human bones of different ages. Standardizing hydrometers.

T. H. NORTON: The occurrence in nature of a copper antimonide. A new apparatus for fractional distillation. Certain alloys of calcium and zinc. The salts of benzene-sulphonic acid with the amines. Some new metallic salts of benzene-sulphonic acid. The amine salts of para-toluene-sulphonic acid. The action of silicon flouride on acetone. The limits of the direct bromination of acetone and on the action between ammonium sulphocyanide and monobrom-acetone. The action of chlorine on acenaphthene. The urates of ammonium and the amines of the fatty acids. Some new nitroprussides.

EDWARD W. MORLEY: Amount of moisture left in a gas after drying with phosphorus pentoxide.

W. H. HERRICK: Improvement in stand for electrolysis. Indirect determination of calcium.

ARTHUR L. GREEN: A process for the separation of alkaloidal poisons, for students' use.

W. O. ATWATER: The determination of nitrogen by soda-lime. Chemical changes accompanying osmose in living organisms as illustrated by the oyster.

ALBERT N. LEEDS: Causes, progress and cure of the recent outburst of typhoid fever at Mt. Holly, N. J. The scientific basis of the feeding of infants.

F. G. NOVY: Analysis of two manganese mineral waters. Some higher homologues of cocaine.

H. W. WELD: Composition of Lockport sandstone.

WM. MCMURTRIE: Notes on the chemistry of germination. Note on absorption of nitrogenous nutriment by the roots of plants.

SPENCER B. NEWBERRY: The significance of "bonds" in structural formulas.

ALBERT B. PRESCOTT: Positive and negative units of valence.

E. W. HILGARD: The processes of soil formation from the northwestern basalts.

C. F. MABERY: A new method for the preparation of anhydrous aluminium chloride. The action of aromatic amines upon certain substituted unsaturated acids. Constitution of the sulphur compounds in crude petroleum oils.

HELEN C. DES. ABBOTT: A compound rich in carbon occurring in some plants.

E. H. S. BAILEY and E. L. NICHOLS: The delicacy of the sense of taste.

SECTION D.—*Mechanical Science and Engineering.*

R. H. THURSTON: Nicaraguan woods. Friction of engines.

ALBERT R. LEEDS: The American system of water purification.

H. T. EDDY: A new method of finding an equivalent uniform load, producing bending moments approximately equal to the maximum moments under a moving train. The deflection of girders and trusses. Reaction polygons and their properties.

CHARLES E. MONROE: An improved method for testing metals.

DEVOLSON WOOD: Effect upon the strength of iron of subjecting it to a pull while hot. Rankine's solution of the problem of turbines. Downward draft device for a furnace.

J. BURKITT WEBB: A new high speed steam engine indicator.

D. S. JACOBUS: Errors of approximate calculations of the effect of the inertia of the moving parts of a steam engine.

J. E. DENTON: The theoretical effect of errors of observation in calorimeter experiments for determining the latent heat of steam. Improved arrangement of Siemen's platinum electrical pyrometer.

T. C. MENDENHALL and JOHN MACK: The uniformity of planimeter measurements.

FRANK C. WAGNER: An analysis of dynamo design.

P. H. DUDLEY: Mechanical inspection of railway tracks and results obtained.

MANSFIELD MERRIMAN: The theories of the lateral pressure of sand against retaining walls.

H. C. TAYLOR: The question of Isthmian transit.

R. E. PEAVY: The Engineering features of the Nicaragua Canal route

J. F. BRANSFORD: Climatic and sanitary notes on the Nicaragua Canal route.

J. W. MILLER: Historical and geographical notes concerning the Nicaragua Canal route.

J. R. HASKELL: National armament.

SECTION E.—*Geology and Geography.*

H. S. WILLIAMS: The different types of Devonian in North America.

EDWARD ORTON: The Trenton Limestone as a source of petroleum and inflammable gas in Ohio and Indiana.

CHAS. S. PROSSER: Section of well at Morrisville, N. Y. The Upper Hamilton group of Chenango and Otsego counties, N. Y.

ALEXIS A. JULIEN: A geological section at Great Barrington, Mass.

N. H. WINCHELL: The granite and quartzite contact at the Aurora mine, Gogebic iron range, Ironwood, Michigan. The "slate conglomerate" of the original Huronian the parallel of the Ogishke sandstone of Minnesota. The Animike black slate and quartzite and the Ogishke conglomerate of Minnesota, the equivalent of the original Huronian. An unconformable conglomerate lying on the Marquette iron-ore rocks at Negaune and Ishpeming, Michigan. The "Huronian System."

J. EDGAR: The Potsdam Sandstone in Southern Pennsylvania.

E. W. CLAYPOLE: The four great sandstones of Pennsylvania. "Lake Cuyahoga," a study in glacial geology.

J. F. KEMP: Notes on the eruptive rocks of the Archæan in the New York and New Jersey Highlands.

JOSEPH F. JAMES: Geological section of Southwestern Ohio.

H. P. CUSHING: Notes on the Berea grit in Eastern Ohio.

JOSEPH E. WILLET: The southern drift.

THEO. B. COMSTOCK: Notes on the extinct thermal springs of Arkansas. The unknown geology of Illinois.

ROBERT T. HILL: Notes on the Texas section of the American Cretaceous.

W. B. SCOTT: The Upper Eocene lacustrine formations of the United States.

J. W. SPENCER: Sand-bowlders in the drift, or subaqueous origin of the drift in central Missouri. Notes on the theory of glacial motion. Glacial erosion in Norway, with some notes on northern ice action.

W. J. MCGEE: The Columbia formation.

JOHN C. BRANNER: The origin of the terraces along the Ohio river between Cincinnati and Louisville. Southern limit of the drift in Kentucky and Indiana.

C. H. HITCHCOCK: Genesis of the Hawaiian islands.

H. C. HOVEY: A description of two caverns near Manitou, Colorado.

FRED. P. DEWEY: Photographs of the interior of a coal mine.

JOS. F. JAMES and U. P. JAMES: The monticuliporoid corals of the Cincinnati group, with a critical revision of the species.

CHAS. D. WALCOTT: Discovery of fossils in the lower Taconic of Emmons. Section of the lower Silurian (Ordovician) and Cambrian strata in central New York, as shown by a deep well near Utica.

L. C. JOHNSON: Notes on the geology of Florida.

J. S. NEWBERRY: The plants and fishes of the triassic rocks of New Jersey and the valley of the Connecticut. The fossil fishes of the Cleveland shale. The flora of the Amboy clays.

WILLIAM M. FONTAINE: The flora of the Potomac formation in Virginia.

D. S. MARTIN: The geology of New York City and environs.

N. L. BRITTON: Recent field work in the Archæan of Northern New Jersey and Southeastern New York.

J. H. MERRILL: The age of the limestones of Westchester County, N. Y.

F. D. CHESTER: The state line serpentines and associated rocks: a preliminary notice of the serpentines of southeastern Pennsylvania.

G. H. WILLIAMS: Exhibition of a new petrographical microscope of American manufacture. Some examples of the dynamic metamorphism of the ancient eruptive rocks of the south shore of Lake Superior.

J. S. DILLER and G. F. KUNZ: Is there a diamond field in Kentucky?

G. F. KUNZ: The diamond found at Dysartville, N. C. Rock crystal from Ashe County, N. C. The agatized and jasperized wood from Chalcedony park, Arizona.

R. OGDEN DOREMUS: On the successful protection of the Egyptian Obelisk in Central park, against the ravages of two winters, by saturating its surface with melted paraffine wax.

RICHARD OWEN: The relation of the pole of the land hemisphere to continents, to the magnetic system and to seismic force. Relation between geographical forms and geological formations.

SECTION F.—*Biology.*

N. L. BRITTON: Notes on the Flora of the Kittatinney Mountains.

H. H. RUSBY: The cultivated Cinchonas of Bolivia.

JOHN M. COULTER: Developments of the Umbellifer fruit.

ROBERT P. BIGELOW: On the structure of the frond in Champia parvula Harv.

W. G. FARLOW: Apical growth in Fucus. Æcidium on Juniperus Viginiana.

W. J. BEAL and C. E. ST. JOHN: Study of the hairs in Silphium perfoliatum, and Depsacus lacinatus in relation to insects.

A. B. SEYMOUR: Characters of the injuries produced by parasitic fungi upon their heart plants.

EFFIE A. SOUTHWORTH: Notes on Catalpa leaf spot disease.

C. V. RILEY: On the Phengodini and their luminous larviform females.

A. J. COOK: On the morphology of the legs of hymenopterous insects.

E. D. COPE: The mechanical origin of the suctorial teeth of the carnivora. The pineal eye in extinct Vertebrata.

T. W. MILLS: On the physiology of the heart of the snake.

B. G. WILDER: Remarks on classification.

R. P. WHITFIELD: Confirmatory evidence of Mastodon obscurus *Leidy*, as an authentic American species.

G. BAUR: On the morphology of the skull and the evolution of the Ichthyopterygia. On the morphology of the ribs.

JOSEPH JASTROW: Locomotion and bilateral symmetry. A point in dermal physiology; with demonstration of a new æsthesiometer.

W. B. SCOTT: Remarks on the development of pteromyzon. Origin of American Carnivora.

H. F. OSBORN: Observations upon the embryological development of the opossum. The relation of the commissures of the brain to the information of the encephalic vesicles. Early history of the foot in Prosobranch Gasteropods.

J. SCHRENK: On the histology of the vegetative organs of Brasenia peltata, Pursh.

W. J. BEAL: A comparison of the epidermal system of different plants.

FANNY R. HITCHCOCK: Preliminary paper on structure of Alosa sapeclissima. On the homologies of Edestus.

C. V. RILEY: The Buffalo-gnat problem in the lower Mississippi.

F. S. PEASE: Honey plant oil. Mrs. F. S. PEASE: The honey plant.

G. MACCOSKIE: The proboscis of the mosquito.

R. H. WARD: On cataloguing microscopical preparations.

A. A. CROZIER: Methods of branching in the fibro-vascular system of plants.

SERENO WATSON: Some notes on American roses.

C. P. HART: Origin, development and prevalency of the so-called Echinococcus.

SECTION H.—*Anthropology.*

W. M. BEAUCHAMP: Aboriginal New York villages.

G. H. PERKINS: Recent archæological investigations in the Champlain Valley. Anthropology as a study in a College course.

T. WESLEY MILLS: Study of a small and isolated community in the Bahama Islands.

CHAS. PORTER HART: On the correlation of certain mental and bodily conditions in man.

E. W. CLAYPOLE: What is it?

J. KOST: The assumed mythical character of Prof. Heer's Atlantis Theory.

Miss F. E. BABBITT: Illustrative notes concerning the Minnesota Odjibways.

STEWART CULIN: China in America; a study in the social life of the Chinese in the eastern cities of the United States.

THOMAS WILSON: History and present condition of pre-historic Archæology in western Europe.

A. WANNER: Relics of an Indian hunting ground.

GEO. F. KUNZ: On a gigantic jadeite votive adze from Oaxaca, Mexico. On a remarkable crystal skull.

D. S. KELLOGG: Some aboriginal dwelling sites in the Champlain valley.

HORATIO HALE: The true basis of ethnology.

D. G. BRINTON: The subdivision of the Palæolithic period.

F. W. PUTNAM: The serpent mound of Adams county, Ohio, and its preservation by the Peabody Museum.

WILLS DE HASS: System of symbols adapted for American Prehistoric Archæology.

JOS. JASTROW: Sensory types of memory and apperception.

F. BOAZ: Music and poetry of the Eskimos. The Niam-Niams of Soudan and their neighbors. The Indians of British Columbia.

S. D. PEET: The Palæolithic age of America. Totemism and animal worship: was it confined to the races who were in the hunter stage?

ALICE C. FLETCHER; On the preservation of Aboriginal remains in America.

A. W. BUTLER: The relation of archæological remains to river terraces.

C. C. ABBOTT: Evidences of a pre-Indian occupation of New Jersey.

F. BAKER: Preliminary studies of platyonemic tibiæ.

M. D. LANDON: The philosophy of wit, humor and satire.

S. KNEELAND: The Santhals of northeastern Bengal.

SECTION I.—*Economic Science and Statistics.*

W. O. ATWATER: Physiological and pecuniary economy of food. Food of workingmen and its relation to work done.

LUCIEN HOWE: The increase of blindness in the United States.

HENRY RANDALL WAITE: The science of civics.

C. S. HILL: Wealth of the Republic.

HENRY E. ALVORD: Relative money value of different kinds of milk and milk products, based upon their contained nutrients.

E. B. ELLIOT: The rates of interest realized to investors in the bonded securities of the United States government.

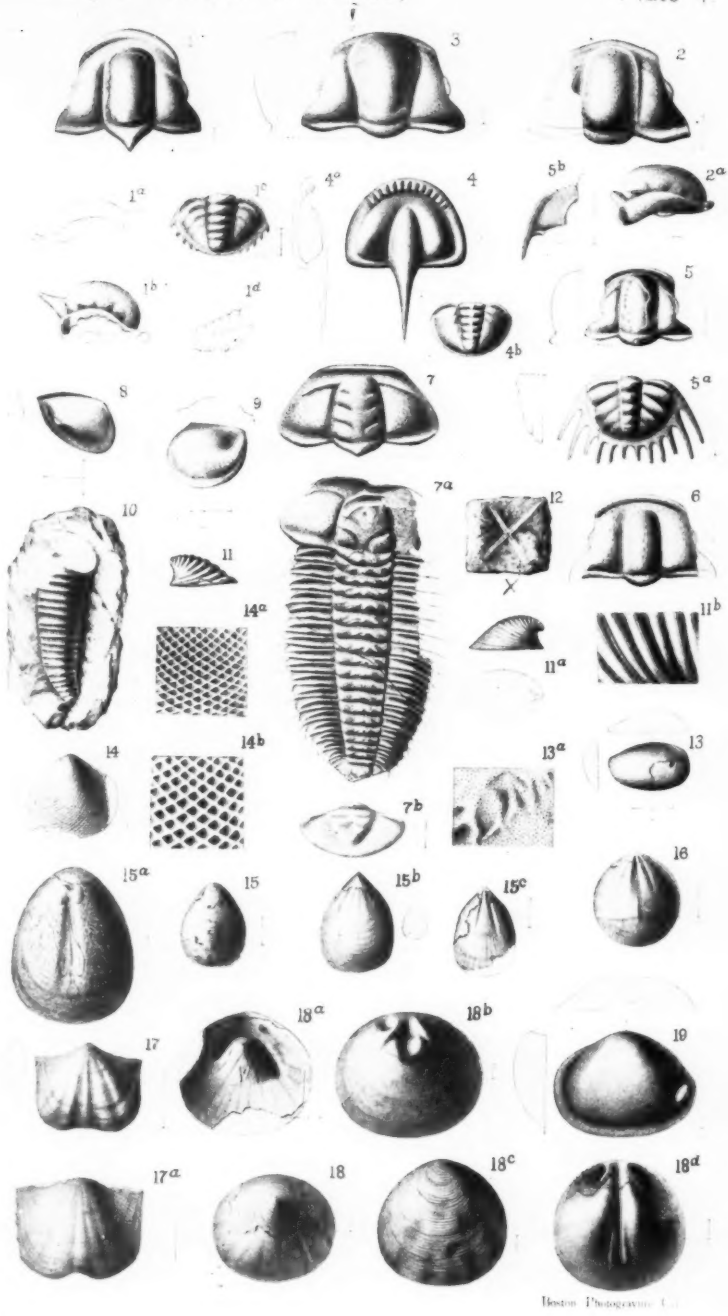
C. M. WOODWARD: Methods and results of manual training.

E. J. JAMES: Manual training in the public schools from an economic point of view. The testimony of statistics as to our national progress.

YAN PHOU LEE: The Chinese question from a Chinese stand point.

OBITUARY.

Professor SPENCER F. BAIRD, of Washington, died at Wood's Holl, Mass., on Aug. 19. A notice of his life and work is deferred until another number.



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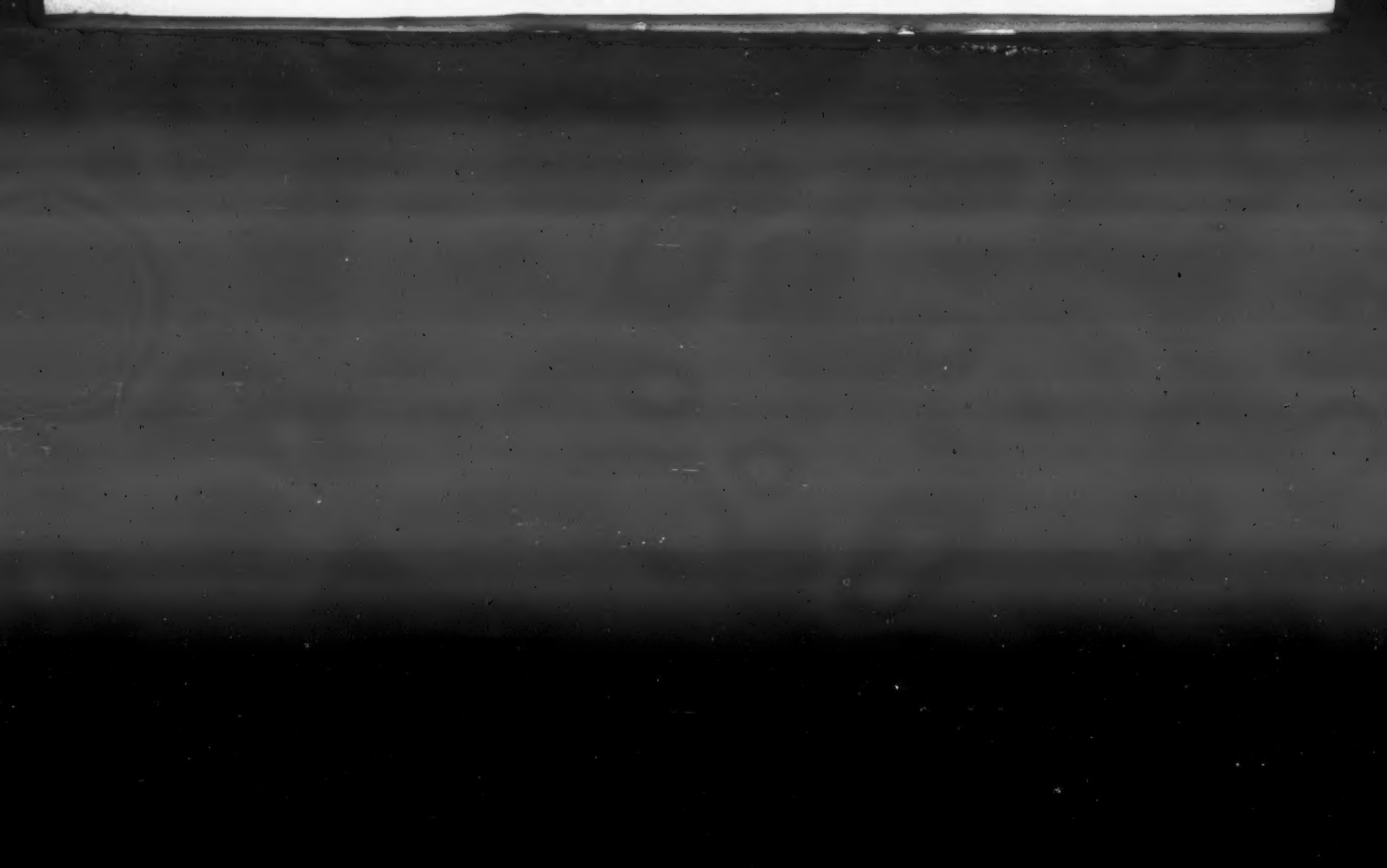

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II. **American Chemical Journal.**—I. REMSEN, Editor. Bi-monthly. 8vo. Volume VIII in progress. $3 per volume.

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Communications in respect to exchanges and remittances may be sent to the Johns Hopkins University (Publication Agency), Baltimore, Maryland.

DANA'S WORKS.

IVISON, BLAKEMAN, TAYLOR & Co., New York.—**Manual of Geology,** by J. D DANA. **Third Edition,** 1880. 912 pp. 8vo. $5.00.—**Text-book of Geology** by the same. **4th ed.** 1883. 412 pp. 12mo. $2.00.—**The Geological Story Briefly Told,** by the same. 264 pp. 12mo. 1875.

J. WILEY & SONS, New York.—**Treatise on Mineralogy,** by J. D. DANA. 5th edit. xlviii and 828 pp. 8vo., 1868. $10.00. The 5th "subedition" was issued by Wiley & Son in April, 1874. (Each "subedition" (or issue from the stereotype plates), contains corrections of all errors discovered in the work up to the date of its publication). Also, Appendix I. by G. J. Brush. 1872. Appendix II, by E. S. Dana, 1875.—**Manual of Mineralogy & Lithology,** by J. D. DANA. 3d edition. 474 pp. 12mo., 1878.—**Text-book of Mineralogy,** by E. S. DANA. Revised edition. 512 pp. 8vo., 1883.—**Text-book of Elementary Mechanics,** by E. S. DANA. 300 pp. with numerous cuts, 12mo., 1881.—**Manual of Determinative Mineralogy,** with an Introduction on Blow-pipe Analysis, by GEORGE J. BRUSH. 8vo., 2d ed. 1877. Third Appendix to Dana's Mineralogy, by E. S. DANA. 136 pp. 8vo. 1882.

DODD & MEAD, New York.—**Corals and Coral Islands,** by J. D. DANA. 398 pp. 8vo, with 100 Illustrations and several maps. 2d ed., 1874.

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